STAFF WORKSHOP

BEFORE THE

CALIFORNIA ENERGY RESOURCES CONSERVATION

AND DEVELOPMENT COMMISSION

In the Matter of:	)
	)
Preparation of the 2008 Integrated	) Docket No.
Energy Policy Report Update and	) 08-IEP-1B
The 2009 Integrated Energy Policy	)
Report	)
	)
Emerging Technologies for the	)
Integration of Renewables	)
____	)

CALIFORNIA ENERGY COMMISSION

HEARING ROOM A

1516 NINTH STREET

SACRAMENTO, CALIFORNIA

THURSDAY, JULY 31, 2008

10:07 A.M.

Reported by:
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Contract No. 150-07-001

STAFF PRESENT

Mike Gravely

Gerry Braun

Golam Kibrya

Pramod Kulkarni

ALSO PRESENT

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AWS Truewind

Jaclyn Marks
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Ray Dracker
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Robert Schainker
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Dariush Shirmohammadi
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I N D E X

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P R O C E E D I N G S

10:07 a.m.

MR. GRAVELY: Good morning. I'm Mike Gravely. Today we're doing what is, in fact, a third workshop in a series of three on the integration of renewables in California. The workshop today will specifically focus on emerging technologies. So we'll get more details on that in a little.

As we start, we have a WebEx going in addition to the people that are here. And so I'm just going to ask briefly if anybody on the WebEx has any problems that they're having before we start, because we will mute all the WebEx people while we're giving the presentations. And then we'll un-mute everybody during the question-and-answer session.

Our plan is to have a brief question-and-answer session for each speaker, and then in the afternoon we'll have a more detailed public comment. But we will have some discussions, but we will have to cut those off if it becomes a time problem. But we are hoping to have each speaker provide a short question session as part of their presentation. So that's the way it will work today.

Logistically for those of you in the building here, the restrooms are outside and to the left here. And if there's a fire alarm or a reason to leave the building, we'll be going out either the door on the left or the door you came in in the center. Right across the street from us is a large park, and we will meet over there until we're back in the building. It does happen, so if that happens we'll just go ahead and exit the building and come back when it's appropriate.

There are too many people to actually do any kind of introduction, so we'll keep the introductions just to the speakers as they go through.

What I will do, though, briefly is --

(Pause.)

MR. GRAVELY: Sorry for the confusion, that's the wrong presentation here. Let's try that again. We got the wrong presentation, give us one second.

(Pause.)

MR. GRAVELY: Sorry for the delay. We ended up with two files with the same name, or very close names. Okay, sorry for the delay there. Two files with very similar names.

The objectives of our workshop today is to specifically this workshop is in support of the IEPR, both the 2008 updated on the integration of renewables, as well as preparing information for the 2009 IEPR.

We're going to specifically today spend most of our effort talking of emerging technologies that can impact the integration of renewables in California, and also that hopefully will allow us to accelerate the penetration of renewables in time for the 2020 30 percent goal.

Also, you'll be hearing presentations through the day on different technologies. And in the afternoon we have some presentations by different technology providers. So one of the questions, also, is determining the actual commercialization states and the validity of different technologies being able to influence California's future.

So we'll be looking for feedback and comments from participants and other individuals who want to participate in the comment session of the ability of these technologies impacting the future in California.

And also when we determine emerging technologies that are critical to the future of California, one of the things we're looking for is to determine if there are things that the state can do to accelerate the implementation of those technologies, the fielding of those technologies, or the use of those technologies.

It ultimately has resulted in a workshop here and the comments we have, and the work that staff has done, will be providing an input to the IEPR that those of you that participate will be able to review as part of the review process for the 2008 IEPR. And will also provide input to the workshop schedule for 2009. So that's the results of what we are planning on doing today.

So the morning session will be starting with a presentation from myself on the Energy Commission infrastructure research and development projects with a quick review of some of our active projects and some of the results we've obtained.

Gerry Braun from our renewables group will talk about the renewable R&D. We'll hear from the PUC about the initiatives that they have, and meeting and working towards the 33 percent renewables.

Then we'll start our more specific discussion from different industry experts on the wind forecasting and high temperature solar thermal storage. We'll break around 12:15 to 12:30 for lunch.

And then we'll come back in the afternoon for a couple of panel sessions. We'll be talking about different specific technologies, and also we'll be talking about, you know, the concept of renewables below the transmission level.

And then, as I said, in the afternoon there's a public session. And we have several people who have asked to speak during that session that we will be allowing them to present information at that time.

For those of you, when you came in, and those of you on the web line you'll get a chance to download this later. We do also have, in the back, we're put together several of the emerging technologies, some information here, handouts -- we've put together a handout that will also be on the website after today for download, with some information on different technologies.

Some that we're covering today; some

that were in addition to what's covered today, because we weren't able to get everything on the agenda. And there's some questions and comments that we're requesting. So there is a specific document you can review.

There are a couple areas we're asking for particular feedback. And the feedback cycle is based on this feedback from this workshop, which is next Friday, at the close of business.

So feel free to pick up these. They'll also be posted on the website as part of this meeting, where all the presentations today will be posted that weren't posted before today.

So, what I want to cover briefly now is the -- you know, my office handles the infrastructure side of the research. And so I want to cover some of those areas in general, and talk about the emerging technologies that we have specifically targeted, that will impact renewable integration and impact the future use of renewables or the future increased concentration of renewables on the utility grid.

The 2007 IEPR, this is actually a distribution system, but it shows the same concept. As part of emerging technology I think we're in an environment where there's a significant amount of changes occurring very rapidly.

And so there's a concept change where the classical distribution system was a one-way system that generated electricity, went down to the customer and they used it, and that was the process.

As we go forward and we look at the new technologies, in addition to very changes in the way we generate electricity, from renewables versus other sources, how we transmit that, how we markets to support that, you'll also see it here that there's a lot of distributed resources. And show you the fact that there's solar and wind and distributed resources, and all these systems that are built.

The grid is anticipated being a two-way grid so that you'll have, in this case, for renewables you can have systems where, in the future, individuals that have renewable resources on their facilities could potentially become a generator or provide net energy back to the grid, as opposed to simply covering their own load.

So all these things we'll talk today,

I'm sure, quite a bit about smart grid. And so one of the elements of all this is the intelligence that's coming, the new technologies that are coming that allow us to use the infrastructure of the utility system, and the ever-increasing infrastructure of the information technology world and communications and control world to make these things work in a different environment than they do today, and provide much more capability and much more flexibility than we have today.

We look at California's infrastructure, it's important to understand we have a unique load profile. And we have a unique system in California. And so that our system peaks in the summer, and it peaks very high from the daytime and the nighttime. And those peaks don't occur a lot during the year. And depending on different presentations, but, you know, less than 5 percent of our energy peak demand occurs less than 5 percent of the time on a yearly basis.

So when you look at different infrastructure solutions and look at different architecture, it's important to understand the way our grid operates, and the value that system provides, our system versus one that potentially may have a much more level and a much more even profile.

The other thing that's important in California is in addition to the renewable portfolio standard we talk about today of reaching 33 percent, we have many other directions and policies that impact us for this greenhouse gas reductions, efficiency improvements, demand response initiatives and other areas.

So, when we look at solutions it's important that we look at all the challenges and in addition to working making renewables work, we have to integrate this into the other challenges that are coming along, so that it makes the problem not quite as simple as if the only issue we had was integrating renewables.

Research is being done, and I'll use this small section here to talk about the smart grid element. We're doing quite a bit in that area, but it is being done from the transmission, the distribution, the integration and the consumer end-use side.

So we are addressing those with some of the technologies. Today you'll hear will be at the transmission level, distribution level. We're not spending a lot today on the consumer end-use side, but those things are also part of it, the renewable elements of it.

A lot of the work we're doing in the future is trying to figure out how to account for and better utilize the distributed renewable resources in the future.

And also the term smart grid comes up a lot. And I think it's kind of like the new green phrase. And it's everything that touches the grid is smart or it's not sexy or not important. So we are seeing that a lot.

But most of the research will indicate that there are some very specific improvements, and very specific values the smart grid brings.

One of them is that people are expecting, as we go to a smarter, more capable grid, of a higher reliability. That's measured in case of how much time a customer is out. How long the customer is out. And come back up. And then decisions that can be made to adjust those times.

Also, there are options to meet reliability needs that we may be able to look at distributed resources much more effectively and much quicker than we do in the past. And so there's options to improve that, this communication and the this ability for the system to work together.

So, we're looking at integrating new technologies, and we're also looking at using our old technologies much better.

As part of this process we are looking at one of the measurements as clear operation and efficient operation and lower cost. So these are always important to business cases. What we do is we look at these new technologies. There are a lot of technologies that are very interesting and very -- they have good features, but the costs or the benefits, at the current time do not match up for the value they're providing to the grid or to California. So we're having to work on those to lower the cost or increase the benefit.

Ultimately we do this for the customer, itself, the end user. And ultimately we're looking to provide those end users more choices of how to meet their energy needs, whether that is with more reliable power, with lower cost power. Whether it's more consistent or whatever it may be.

We want to provide better options to the end consumer. And we want to provide those at a lower cost on the overall total cost in the future.

If you look at the different phases of the research you'll hear a little bit more about this this afternoon. But in the transmission area one of the key areas that have evolved in this new technology impacting renewables, is phase technology.

It's an ability to measure the state of the system, something in a range of 30 times a second. And that information is then portrayed back to the decisionmaking authorities at the ISO or the utilities. And we were putting these devices in throughout California.

And our group has been working both on the technology and the measurement, as well as the use of the data, developing displays for the ISO and developing information on how to take this data, better predict this into the grid with the ultimate goal of as we increase more and more renewables on the grid, the general perception is the grid stability will suffer. And therefore we need better ways to manage that stability and respond with other resources.

Also, from the -- this is one of end customer side, but many of you are aware, as I mentioned earlier, the goal for demand response. And the use in that resource in California.

What the emerging technologies allow us to do is automate that and to use that for other things. In this case we've been doing some research where we can actually use demand response as a grid resource for spinning reserve. We could use it for renewable firming and renewable support.

And so this is an opportunity to use load in a smart manner, to allow us to actually respond to the needs of the grid and the changes in the grid that are occurring as a result of the higher penetration of renewables, as opposed to always having to put in new power plants.

In addition to that side, we also have work in commercial buildings in the industrial side with automated demand response. We've had a very large increase in that area. We've developed some pretty specific standards and work in that area to make this across-the-state standard.

But what happens here is in addition to

the residential people, we're looking at automating commercial buildings, lighting, HVAC and industrial processes. And being able to use that again as either a resource that's bid in the day-before, or a resource that's used the day-of to help control the grid.

Grid security is another area where we are cautiously looking at that. Ultimately if the electricity can't get to the end user, the security element of it or the terrorist element of it, or the just overall concept of the flow down from the generation to the end customer, we are looking at those types of systems. Looking at vulnerabilities in the systems, and looking at new technologies that will allow us to address these problems before they go.

Ultimately, in this case, if the grid, itself, doesn't operate, the renewable resources won't be able to go anywhere of use.

Hardware development is also -- you'll hear some more this afternoon of some different hardware approaching the commercial phase, or near commercial phase. This is just showing you one example of where we're doing work in fault current limiters to help the stability of the grid, and handle problems with different technologies.

There are three different technologies that are in phases of being evaluated and demonstrated by different utilities. But the ultimate goal here is these things provide new flexibilities and provide the grid ability to operate at higher capacity rates; and also to allow us to put more renewable resources through the existing system.

We're also looking at the use of intelligent agents to work as a system that would allow us to make decisions onsite to respond. We have a demonstration project that we're doing where we're integrating storage and wind and other issues. And working directly with the ISO on a signal basis to allow us to communicate and then make those decisions in a real-time basis. And then provide the results of that back to the decisionmaking authority.

So here is an example where we're integrating intelligent software communications and control to allow us increase the utilization of renewable resources at times of need.

Energy storage is an area where we'll hear more about today. I'm just going to talk briefly because it's one of the topics that we think that has a huge opportunity of supporting California's needs in the future for renewable integration.

There is a full spectrum of storage. On the upper right side you can see compressed air, which would be hundreds, if not thousands, of megawatts, to large systems like hydro, and down to systems like flywheels and batteries and other systems, other smaller compressed-air systems. And even ice storage systems. To use that storage as it will help us to store the renewed energy and use it at a time of high value.

Energy storage in general is used in the area of this just shows you the graphical representation of load leveling, where you're taking this energy storage at night and using it during the day.

You're using the energy as you have rapid accelerations or the ISO is calling for lots of -- energy storage can be used to help level that out. And, of course, frequency regulation. As the grid operates all the time and has variations as it matches load and generation. And storage is one of the technologies that has the ability to help there.

As we do more and more renewables, the perception is that prediction of that load versus generation may be much less reliable. And so the use of these things like storage and demand response under loads types of systems make it very useful for controlling the frequency in a much more cost effective manner than the classical approach of adding more spinning reserve, or adding more generation just to sit there in case there's a need for that energy during one of these events.

This is just a quick collage of the types of technologies that are currently being evaluated, both by the Energy Commission, by the utilities and by industry.

And we've done several of those projects. This shows you just a quick example of where the different technologies fit. If you look at the bottom we're talking about everywhere from small systems that may be in a residential system or small business of 1 or 2 kilowatts, up to tens and hundreds of megawatts that would be part of a grid system or part of a system that would support a utility.

And this just shows you from today's technology where these fall. And I think you'll hear a little bit more this afternoon from Dr. Robert Schainker about some of these applications.

It is important to understand one of the questions comes up is if we have a renewable portfolio standard going forward and we need so much storage, one of the research we've been looking into is if we make up the (inaudible), and let's just say nominally we decide we want 5 percent, 10 percent, 15 percent of the load to be supported by storage, this chart just shows you that in the reality of the next five years, if we made a decision today, you know, hydro, pumped hydro and compressed air are capable of providing tens if not hundreds of megawatts.

If we're trying to use newer technology, I think there are lots of vendors who would love to sign a contract. But the reality of it is of getting 100 megawatts of a new battery, or 100 megawatts of flywheels is something that we just aren't to that point yet.

So this is one of those areas where we think going forward it would be better to find a need for storage as integrating with renewables.

We may want to encourage some of these new options by demonstrations and by incentives to bring those systems forward. If it's a decision in the state that's what we need to meet our future needs.

That one didn't come through, but what I was going to mention here is we have been doing some research, actually through EPRI -- I think you'll hear a little more this afternoon -- looking at California and underground sites where we could do compressed air.

So if the decision were made by the state that we need large amounts of storage, that's one of the options that could be considered.

We've also done research with communicating with the ISO. This communication architecture can be used by many technologies. This particular one that's used with flywheels and it was used for spinning reserve.

But the architecture in the middle and the lessons we've learned on how to do that, and how the signal provides -- it was very useful and it's being used in other resources today, in addition to this project that's over with.

This just shows you that evaluate

technologies. In this case we evaluated the flywheels of going for a minute up and a minute down, max to max. We tried to see how well they performed.

Some systems, if you're going to do frequency response, those are loads that change very rapidly. So there's a need to absorb energy, there's a need to provide energy very rapidly. It could be in a four-seconds-or-less basis. Some technologies respond well to that; some technologies don't.

This is an example where we just run some results tests on that to determine what it could do. We also did some reliability testing to determine how well the system could respond on a monthly basis. And collected the data and we've done this information to share. This is, again, one example of one technology.

So that was a quick overview. What I'll do now is open up the lines if there are any questions. And we've got a few minutes here to take questions on this area before we go to the more detailed presentation on renewable technologies.

If you have questions please come up to

the mike, introduce yourself so we can record your question.

Any questions at all? Sure.

MR. DRACKER: Hi. I'm Ray Dracker from Solar Millennium. Interesting overview on all of the pot pourri of things that are going into the so-called smart grid program.

I don't know if you've gotten this far in your analysis, but I sort of have a basic quantitative question that you might not have an answer to, but I'll ask it just for the fun of it, as it relates to both intermittent renewable energy.

My company's a bulk intermittent renewable energy company. And, you know, if all goes well hopefully we'll be supplying the state with 3 terawatt hours of this stuff within eight years.

A couple years ago I did a big study with the CEC for the CPUC on what the outlook was for 33 percent renewables. And one of the things we had to do was predict, as a function of penetration, what the integration costs were going to be for bulk intermittent renewables through a 33 percent deployment. And I think I drew a curve somewhere that had numbers on it.

Let me get to my question. If all goes real well with this smart grid stuff, how much will you reduce that number by in five years?

If the integration cost of bulk intermittent renewables is $10 a megawatt hour without smart grid, how much will it be with a really well implemented smart grid program? Would it be zero? Will it be $5 a megawatt hour? Will it be -- will it have no impact at all? Will it be $10 a megawatt hour still?

MR. GRAVELY: First of all, I would tend to agree. I've yet to see those specific comparisons, but we, as part of the IEPR process, and as part of the future IEPR process, we have done several scenario analyses where we look at different mixtures of generation and renewables, and meeting the different standards and how it fits, and looking at cost allocations.

So we have pieces of it being done. There's one area that we're doing within our office, and there's an announcement out there, we're doing a smart grid 2020 research project where we're trying to define the smart grid for 2020.

And one of the questions is the question that you answer here. When someone determines at 2020 this is what we're going to have, the question, what's the business case for making the decision.

Ultimately, as I said before, the purpose of smart grid as we go forward is to allow things to operate cheaper, more efficiently and get better information you have.

So I would say -- why don't you put them on mute. Somebody's got some background noise; they're typing it sounds like.

So I think those are good questions. Those are the types of questions that we're looking for as part of this workshop. And so I would encourage you to make those kind of comments.

One of the things we look for in addition to the IEPR input, we also look for research priorities and those things. And I think it's an area, cost and the way you expressed the cost and the value of smart grid is an interesting way of looking at it.

But I don't think -- I have yet to see anybody put it in that perspective. I do believe the ultimate goal of where we're going with smart grid is to be able to do those types of things and reduce the cost. And be able to do more, you know, with less resources.

MR. DRACKER: Yeah, very parochial, and I know there's a lot of different reasons for doing the smart grid. And that's all great stuff. But again, I -- what I'd like you to do is when Cal-ISO and the PUC say that the cost of integrating lots of solar thermal is going to be $8 a megawatt hour by 2018. So we've got to add that cost to everyone's bid -- turn around and say, no, it's only going to be $3 because you got to do all this smart grid stuff.

See, that's the practical short-term value of some of this stuff.

MR. GRAVELY: Okay.

MR. DRACKER: So, anyway, enough said. Thanks.

MR. GRAVELY: Thank you. One more question? Anybody have -- anybody, you can ask if anybody from the --

MR. SHIRMOHAMMADI: I have a question. Can I ask --

MR. GRAVELY: Sure.

MR. SHIRMOHAMMADI: Is this thing working?

MR. GRAVELY: Talk into either one; yeah, either one.

MR. SHIRMOHAMMADI: You had a slide that showed the magnitude of various storage technologies. Could you go to that slide, please? That one.

MR. GRAVELY: This one, or --

MR. SHIRMOHAMMADI: Yeah, that's the one.

MR. GRAVELY: This one here?

MR. SHIRMOHAMMADI: No, the other one.

MR. GRAVELY: Oh, this one here?

MR. SHIRMOHAMMADI: That one, yes. And there you mentioned it's not possible to get to certain megawatt numbers anytime soon. Could you elaborate on why?

MR. GRAVELY: Yeah, yeah. I think what happened, the purpose of this research that was done for us was we asked a question, is, for example, in some areas of the country there's a 10 percent rule, for example, in renewables, wind. Some countries require 10 percent storage when you put in wind.

And we had a research project where we went out and talked to all the vendors, and the industry, and the ISO and said, you know, what are the needs for the future. And the ISO sent us a letter saying, we'd like, you know, 250, 500 megawatts today or tomorrow.

And I said, well, you know, if the question is we want hundreds of megawatts in a few years, we said what technologies can actually do that. And what we're showing here, I base it on what's out there. I mean, you know, one of the problems with new technologies is there's an element of just because I can build a 10 kilowatt system doesn't mean I can build a 10 megawatt system and it'll work the same.

So, there's a growth pattern. So we have lots of technologies. There's propositions in California now to put in anywhere from 50 to 100 megawatts of storage, megawatt hours, in range of 1 to 5 or 10 megawatts rating in the near future, in the next year or so.

So the question here we were looking at from a policy perspective is if the state policy and the questions came to us saying we need, based on the introduction of 3000, 4000 megawatts of wind, we need 300 or we need 600 megawatts of storage.

The answer is, if that's true, then the way you're going to get that in the next three to five years is either compressed air or pumped hydro. You're not going to get that from, in our belief, at least in the research we've seen, from flow batteries or from lead acid batteries or from flywheels. And depending on how long you want it. If we're talking about storage that's going to last several hours as opposed to several seconds for one of this application.

So we also looked at the technology, itself. Now, obviously we are a strong advocate - - I'm a strong advocate of energy storage technologies and working real hard to demonstrate those and move those, but there's also a realistic perspective.

If storage becomes a key element to meeting our 33 percent renewable portfolio standard in 2020, the mixture of storage is going to be smoothing like this as opposed to us investing in a flow battery or something, and putting out 300 megawatt flow battery systems to meet the needs.

It's just -- and Robert may share later some cost numbers. These technologies, also the reason they're out there in the 100 megawatts, when you build them that big the price per kilowatt hour is very cost effective for large systems.

It's very expensive to get there, but when you build large systems it makes sense. If you're building smaller systems, that's why these systems are very prominent in the marketplace, is it costs a lot to get these first two in the field.

But if you're looking at hundreds of megawatts that cost is there. If you're looking at 1 or 2 megawatts, it doesn't make sense.

MR. SHIRMOHAMMADI: I'm still at a loss. These numbers would show where we can be in about five years or so. Is it based on what the need is? In other words, Cal-ISO told you, I want 1000 megawatt of hydro versus that acid battery; or is it based on your, the other view that what can be done in five years?

MR. GRAVELY: Well, we'll let -- actually, Dr. Schainker there actually developed this research for us, so I'll let him help us.

DR. SCHAINKER: Yeah.

MR. GRAVELY: He can give the specifics of the chart and also the data. But I think it was the second part of your question.

DR. SCHAINKER: Yeah. Dariush, good questions. I actually developed this chart so I can talk to you offline if necessary. But the fact of the matter is what this chart represents is what is available. Not what the need is, but what really is available.

In tune with what Mike just said, if the grid, ISO operator needs, you know, 500 megawatts of storage, or 500 megawatts of ramping and regulational, what is out there today and what we predict would be there in the next five years to actually deliver that -- and this is a good representation of it.

Now, this is per module. This is approximate megawatt power levels per module --

MR. SHIRMOHAMMADI: Okay, okay, it's not total --

DR. SCHAINKER: Not -- now you could have, if you had 10,000 sodium sulfur batteries and they were all working well, yeah, then you could probably deliver 500 megawatts. But that's unlikely.

Per module this is what's available today. Not to say that we wouldn't need and like to have something better than that, this is what's out there. And we shouldn't fool ourselves.

MR. GRAVELY: Okay, thank you very much. Interesting on schedule here, and I'm going to turn over the podium to Gerry Braun and let Jamie bring his presentation up. And thank you very much.

I would encourage you to take the handout and provide us questions across the area also in addition to comments from the workshop. Thank you.

(Pause.)

MR. GRAVELY: We're having an unusual problem with the technology.

(Pause.)

DR. SCHAINKER: We not only need a smart grid, we need a smart projector.

(Pause.)

MR. DRACKER: Could I ask another quick question while they get that downloaded?

MR. GRAVELY: Sure. Just go up there; I'll be glad to answer.

MR. DRACKER: Just looking at that last Vugraph, if you -- the equivalent of that Vugraph that you would have done in 1991 would have had a macroSMES on the far-left side at 500 megawatts, there were utilities killing each other to be the host utility for whatever, you know, the macroSMES.

MR. GRAVELY: Well, the macroSMES was a demonstration unit.

MR. DRACKER: Right.

MR. GRAVELY: There was not a commercial unit available five years ago, yes.

MR. DRACKER: Right, but since 1991 we've had huge advances in cryogenics, in superconducting materials and power electronics. However hard it was to do macroSMES in 1991, it should be easier to do it today. Except we have 15 years of lost momentum.

But my question is a simple one. Is that technology dead forever?

DR. SCHAINKER: I would never use the word forever in an R&D environment that I support. But generally speaking, what's happened with macroSMES, large, you know, 1000 megawatt five-hour SMES, the engineering test model that was being looked at about 15 or even 20 years ago.

What's happened with SMES is that the costs have tripled and quadrupled since -- even in constant dollars. The cost to build SMES, even with warm or hot superconductors at 77 Kelvin, et cetera, rather than we were looking at 11 Kelvin at that time, but the costs have just gone way way up.

MR. DRACKER: Okay.

DR. SCHAINKER: And what's happened with SMES is that the only niche market that looks attractive with it today is for very short discharge times, in seconds, --

MR. DRACKER: Right, I understand.

DR. SCHAINKER: -- even half a second, rather than in hours. That ETM device, engineering test model, --

MR. DRACKER: Right.

DR. SCHAINKER: -- was looking at a five-hour --

MR. DRACKER: Right.

DR. SCHAINKER: -- 1000 megawatt device. A five-hour, 1000 megawatt SMES device would cost probably $30,000 a kilowatt today.

MR. DRACKER: Okay.

DR. SCHAINKER: When we were thinking 15 years ago we might be able to build it in those dollars, oh, for less than $1000 a kilowatt. So things have changed dramatically for the bad side on SMES.

And, yes, technology's gotten better, but the cost has just far exceeded the advancements in the technology.

Now if somebody would ever develop a so-called room temperature super -- magnetic material, the holy grail of room temperature, then we'd have a whole different picture with SMES. But we're not there yet.

MR. BRAUN: Okay, ready to go on. I'm Gerry Braun; I'm going to talk about the flip side of what Mike was talking about. Mike talked about adapting the infrastructure to renewable energy; I'm going to talk about adapting renewable energy to the infrastructure.

I'm going to take it from the technology perspective to the resource perspective, and then talk about integration of different dimensions of renewable energy integration. And then some of the programs that we're launching to deal more directly with renewable energy integration issues.

This is the no-silver-bullet chart. On the left-hand column you'll see the menu of renewable energy technologies. Some of them will be fairly familiar.

At the bottom of the list, appropriately, are some of the low-hanging fruit of renewable energy. We in California did a good job in the 80s of launching some renewable energy industries, but that was through PURPA. And what we didn't launch were renewable energy industry to deliver thermal energy, cooling, hot water, heating and that sort of thing.

So, the other dimension is that renewable technologies either have economies of scale that make them want to be deployed as large power plants, or they have modularity that allows them to be deployed on buildings.

And some of them can scale in other directions such that some of them can be deployed in an intermediate scale that I'm referring to as community scale.

Just to remind us, as I said, California was the launchpad of several of our global renewable energy industries through the implementation of PURPA in the 1980s, including the wind industry, biomass and the concentrating solar thermal electric industry.

And California has another dimension that's really important to remember, and that is relative to other countries and other states we are renewable energy resource rich.

We have the best solar energy radiation for concentrating solar and total solar radiation. We have the best geothermal resources. We have world-class wind resources. And we have substantial agricultural and forestry waste streams.

And we're also renewable energy R&D rich in the sense that one-third of all global investment, venture capital investment in clean energy, mostly renewable energy, comes from California.

And we have a legacy of far-sighted, ratepayer-funded R&D in renewable energy. First couple decades led by our utilities. And the Energy Commission has picked that up and moved it forward.

We have actually in California also some policy or market interventions. Modest, actually, by global standards. Over ten years an average 20 to 30 percent subsidy for photovoltaics on buildings. And a portfolio standard that obligates our investor-owned utilities to bring on significant additional quantities of renewable energy.

This chart some of you are probably familiar with. I've rearranged it a bit. The over-arching policy in California that we're being driven by is the AB-32, the reduction in greenhouse gas emissions.

And then there are other policies that impact renewables at the different levels of the market. The big renewables, we have the portfolio standard; and the building-integrated renewables, we have, as I mentioned, the California Solar Initiative. And also the IEPR recommendations from 2007, which set a target of zero energy new residential buildings by 2020, and zero energy commercial buildings by 2030.

And then in the mid range we have some very specific bioenergy, biopower, biofuels targets that really probably apply at the community scale.

We need to keep our thinking about renewable energy integration in context. The global investment in renewable energy in 2007 approached $150 billion, which is two and a half times the total global investment in commercial aviation. It's not a small industry anymore.

What we're going to see as a result are new technologies that are being commercialized elsewhere coming into the California market. And we need to accommodate that through our R&D programs and our policies.

I mentioned that renewable energy integration has multiple dimensions. We're, today, focused on the dimension of integrating supply and delivery. But we also need to think in terms, at the building scale at least, integrating renewable energy and efficiency.

And in terms of more traditional electric system planning, we need to -- we used to talk about optimizing the cost of generation by the appropriate levels of baseload, intermediate and peaking generation. Now we're kind of talking about baseload, intermittent and peaking generation.

We need to strike a balance between where renewables are deployed, whether at the remote areas where the resources are excellent.

Or onsite in buildings. Or in the local communities where there may be opportunities.

Size, as we talked about, we have different sizes of renewable options, just as in the case of storage. And we need to consider that.

Technologies, I'll talk about this a little bit more later, but we have obviously commercial technologies and emerging technologies. We need to account for that. And we are looking at renewable energy technologies that will be enabled in their integration of the market by other technologies, such as energy storage.

This is a conceptual chart, I would say, it's not accurate. I borrowed it from a colleague. But what it does is help put in perspective that we have different renewables that -- renewable options and resources that will fit together in ways that create an optimum and an economically least-cost mix of supply.

Baseload resources, biomass and geothermal, intermediate capacity factor resources such as wind. and then solar, which is, as we know, matches our peaks in California well. And with the integration of energy storage, can be shifted around to perfectly match our peaks. So I just wanted to kind of give you that perspective that we could look for a renewable energy-based future because we have the resources, the mix of resources that other folks don't have, to work with.

Commercial versus emerging. We're talking here today about emerging technologies. And I just decided to use the chart I showed before to kind of differentiate between technologies that are commercial, are commercially available, and those that are more in the still-developing category.

And you'll see, if you scan across this, that several technologies are both. We have, particularly where there is substantial venture capital investment; we had a commercial menu of technologies as in photovoltaics. And an emerging menu of technologies. Also, for example, photovoltaics, biofuels and some of the other technologies where there's substantial DOE or venture capital investment.

And something we need to account for that it's not just the technology that we need to look at in terms of differentiating commercial versus emerging, it's the infrastructure to deliver the technology.

And the picture here isn't quite as heavy with -- in California. We have the commercial capacity in several of the big renewables areas, and some other areas. But, again, because the thermal renewables, renewable energy heating and cooling technologies, didn't benefit the creation of industries and retail infrastructure in California did not benefit from PURPA. So we don't have the legacy of industries that were spawned by previous policy interventions.

And these can be very big contributors in the future. And we need to think about them in the integration context.

I want to turn to our research and development programs very briefly. I want to talk about some of the things that we are doing that are aiming our program more in the direction of integration.

First of all, our renewable energy collaboratives, we sponsor these, the Energy Commission sponsors these. These are statewide networks of government, industry, environmental groups and educational institutions. You'll hear from one of our collaborative leaders later today, Case Van Dam from the Wind Collaborative.

The technical staffs execute collaborative research that address both the front end, the headlights of our RD&D programs, and also stakeholder priorities. And we have three collaboratives in place; a fourth dealing with solar energy is being -- is in the formation stage.

What we expect in terms of research contributions from our collaboratives. First, we need, as I said, headlights, we need to look ahead in terms of the cost and performance that we can expect from renewable energy options. And the improvements that will be coming, driving by the scale-up of the industry, of the incremental innovation that the industry will be doing automatically as it competes.

We need to assess the next generation, the emerging technologies. And we, definitely from a planning perspective, in terms of coming up with the optimum mix and deployment of renewable energy, we need technically validated supply curves for all of our major renewable energy sources.

And we need to do that in the context of scenarios that would achieve even greater levels of renewable supply in the future.

What we're doing with the collaboratives is to try to stabilize the research programs by putting in place two-year funding for the four collaboratives. And we are looking to the collaboratives to create the kind of research collaboration that we were blessed with in the earlier stages in California, where the Energy Commission, the Department of Energy, the utilities and the research institutes of the utility industry were all working together on specific projects. And we're hoping to recreate that.

So that was the research, the front-end of our program. I want to talk a little bit about our development and demonstration strategies and efforts.

We have three potential strategies. We have a limited amount of resources that we can apply to renewable energy R&D at the Energy Commission. We could use those resources to create new options, to improve existing options, or to enable deployment.

And quite clearly, now that we have a very aggressive RPS, our emphasis needs to be on the latter. And so we are emphasizing renewable energy integration. And in doing that, we're targeting the technology gaps that occur when you're trying to put new technology into new places.

And also optimizing the economic value. When we're talking about a mix of renewable energy resources, we need to understand how that mix will occur at different levels in the market.

And then, of course, Mike and his colleagues are working on the optimization of transmission distribution to accommodate increasing levels of supply.

So we have three new programs with solicitations planned for later this year. One deals with utility-scale renewables. And the target really is enabling technologies. We're looking at a situation where at least in solar thermal electric there's a development boom going on. Ray can talk about that a little bit later. Proliferation of solar thermal technical solutions. We need to really sort through that and help the policymakers sort through that.

Integration of thermal energy storage and natural gas in solar thermal electric plants is going to be a key issue. The existing plants are natural gas hybrids. The future looks like it wants to be more integration with thermal energy storage, but it may be that both hybridization and energy storage will work together. But perhaps in different ways than in the past.

And then we'll be hearing from John Zack about forecasting. But thinking really broadly, think about a building energy system that is smart. For example, with solar sources, electric and heating.

It will be helpful to have real-time forecasts of solar energy delivery to the building if it's smart enough to figure out what to do ahead and has energy storage and that sort of thing. So we have a lot of potential need for better, real-time resource forecasts in the future.

And, of course, now we're focused on what does Cal-ISO need. But there are a lot of other needs that will be served if we can bring this kind of capacity onstream.

Our targets for the solicitation, and these are just some of the targets, thermal energy storage and forecasting. And try and understand the high value integrated solutions that involve storage and wind and solar and natural gas.

The second solicitation, this one is probably the first one that will be coming out. Related to this intermediate level of deployment. We're calling it renewable energy security communities.

And there are many communities in California that are actually looking to renewable energy as an economic component, as a component of their future economies. Trying to get to, you know, full reliance on renewable energy.

And they're doing it for a reason, and that is to stabilize their energy costs; to put themselves in a better competitive position; to generate jobs; and their goals are going to be stability for energy cost, for the local renewable energy resource. And they're certainly going to integrate renewable energy deployment with efficiency and demand response capacity.

So, we're excited about this initiative. Our solicitation targets are to help the communities take the next step down the road, addressing scale-up risks and innovation opportunities that are available.

And actually build the technical infrastructure. And one way we can do that is to tap our university campus communities. Some of them are well along toward this concept of basically self reliance in terms of energy. And they also have the ability to train the next generation of engineers and practitioners in this area.

Just to mention, we are planning for this particular solicitation, and we'll be doing this for all of the solicitations, workshops to just talk about the subject, to talk about the topic, talk about the issues and try to get input to finalize the solicitations.

So we have three workshops scheduled on August 6th here at the Energy Commission; August 8th in Downey at Sempra; and the 12th at PG&E in San Francisco.

I mentioned earlier the -- and I'm talking now about turning to renewable energy secure buildings -- other parts of the world that are moving forward with renewable technologies in a different way than we are here in California.

I point to Europe in the case of buildings. The European Union plus Switzerland, that's what the EU-27 plus CH is, have policies in place to encourage renewable energy heating and cooling.

As a matter of fact, there are now large conferences on that subject. Not here in the United States, but in Europe. And in fact, Europe is, in a very short period of time, is at the level of generating about a thermal gigawatt of heating from just solar collectors. Not photovoltaics, but thermal collectors.

So, we're looking at renewable energy secure buildings. We'll have a solicitation in this case. The technical gaps that we're looking at relate more to the products that will be wanting to come into the market. And there's a whole set of technical infrastructure requirements there that we can support including testing, evaluation and rating of products, product innovation, field tests, codes and standards support, and technical assistance to architects and builders.

So we will be targeting these types of

things in our solicitation. And we may take a page out of the book of the efficiency programs and look at the possibility of a California renewable energy product technology center. So, we're looking at some new approaches.

In summary, as I've said, we're seeing that global energy deployment is going to drive incremental innovation and cost reduction. That's happening. We don't need to drive it from here.

We are, in California, the best venue to understand renewable energy integration. We have so many resources, including the technical capacity and the resources, and our utilities are very progressive. We have the ability to lead the world in understanding renewable energy integration.

We have to address all dimensions of renewable energy integration. And there's more than just the supply delivery dimension.

We need to look at scenarios for a totally renewable energy based economy. And we have a somewhat uneven industrial capacity in terms of renewable energy supply. We need to kind of balance it out. Right now it's all electric. But the thermal uses of renewable energy are going to be important.

So, our priorities, research that's driven by the vision of a renewable energy based economy. And development and demonstration of the high value integrated solutions.

Thank you very much. And I have left about five minutes for questions.

Robert.

DR. SCHAINKER: Gerry, Robert Schainker. I really appreciated your presentation and thank you very much.

In particular, I had never seen this concept before -- but it really is quite straightforward now that I think about it -- is the idea of having base, intermediate and peaking renewables. That slide you showed was very informative, so I thank you for that.

My question, though, is a little different. And that is, and I would think that you have this, I just didn't see it in the slides yet, the carbon dioxide savings that would occur for different amounts of penetration of various types of renewables. I'm sure you have that, but it would seem this would be very important to present to particular political audiences in the state.

So, maybe you want to comment on that.

MR. BRAUN: Yes. And I welcome that comment and I agree with it. And I would mention that I think one of the next things we need to do is to look at the CO2 impact of some of the heating and cooling options.

You know, 15 percent of our residential energy consumption is water heating. You know, we have states that are basically saying all new water heaters are going to be solar. We haven't gotten to that point, but that could have a big -- you know, that would have a material effect on our greenhouse gas targets.

And, as you know, as we all know, that half of our energy supply goes into buildings. And a big share of that is heating and cooling.

And so I think that when we look at those numbers we're going to be impressed by what might be possible. And having said that, I would say that, you know, we don't have the blessing of an industry out there that is, you know, doing the work that has to be done to get the policies in place that are needed for this to support the kind of deployment we need.

There's kind of a chicken-and-egg thing. You need the industry first, and they promote the policies, and then the policies come and promote the industry. We're starting from almost a standing start here.

Other questions? Okay, maybe we've made up about three minutes on our schedule.

(Pause.)

MS. MARKS: I'm Jaclyn Marks and I'm a policy analyst at the California Public Utilities Commission. I work on implementing and developing policies for the renewable portfolio standard. And I would like to thank Gerry for the opportunity to be here today, and also for your very informative overview of PIER's new direction on renewable energy research, development and demonstration. And your focus on enabling technologies.

I think what I'm going to present here today will complement the work you're doing. And I'm really excited about that because with limited state resources we always want to make sure that we're complementing each other's efforts, and not duplicating them.

My first caveat is I'm here to speak

mainly about the emerging renewables resource program. But this program has not yet been approved by the PUC. It's a proposed decision at the time. So when I say we, I'm not actually speaking for the Commission. I'm either speaking on behalf of my own views, or the views of my colleagues in the energy division.

So, last July PG&E and SDG&E filed the ERP application. And the primary ERP activity that the utilities are requesting is to demonstrate renewable resources or technologies that have completed preliminary assessment or testing, but require performance validation to confirm their feasibility for commercial use.

So the focus is on demonstration to bridge the gap -- to bridge the valley of death for mostly emerging renewable technologies, generation technologies. But this also could include enabling technologies such as storage or other technologies that facilitate grid integration.

PG&E requested $30 million over two years, and SDG&E requested $15 million over two years. And many are probably wondering what about Southern California Edison.

Well, SCE did not participate in the ERP application. Last March they filed their own application for a renewables integration and advancement program. Their request is for $30 million over two years to focus primarily on grid integration.

That application is still under review at the PUC. It's in the very early stages. And one question we are exploring right now is what are other state agencies or private companies doing in this area, so that we avoid duplication.

So, I could see a lot of work that PIER is doing in that regard. So I think this has been a really great discussion so far.

PG&E and SDG&E together have only requested funding for three projects. Once the -- if the application is approved they will submit requests for additional projects.

And the three projects at the time include a UC Merced solar testing center. PG&E requested $2 million to fund the center. That's only part of the funds, and they would be looking for funds from other sources.

For a wave connect project to test new wave energy devices across the Mendocino-Humboldt coast. But that project is still in the very preliminary stages. So the money they're requesting at the time is for a feasibility study.

And then a wastewater biomethane demonstration plant in San Diego to demonstrate the feasibility of turning wastewater, natural gas into pipeline quality natural gas.

So, we in the energy division see the ERP program consistent with the central recommendations of the economic and technology advancement advisory committee, the ETAC, to AB-32 and limitation. They're advising the Air Resources Board on emerging technology issues.

And one of their central recommendations is to promote clean energy innovation and commercialization, especially demonstration finance for clean energy.

And one quote that I thought was particular significant relates to the rationale for approving ERP is, in the view, absence of funding for project demonstration is a significant impediment to the maturation of new technologies. And it's consistently identified by thought leaders as a major gap in the financial architecture of clean energy.

Public sector managers view demonstration as the responsibility of the private sector, while private sector investors view it as too risky. So this is really one of the main rationales for doing demonstration technologies.

In terms of the CPUC's rationale for why ERP is important, we, in the energy division, think that it fills a gap, an important gap, in the RPS program. The RPS was designed for commercially proven projects, not emerging technologies. And our current contract evaluation protocols are not designed to evaluate precommercial technologies.

So the utilities have submitted power purchase agreements for our approval for emerging projects. And a lot of these projects are significantly greater than the market price referent, the MPR, and require above-market funds.

So, in our view, it would be more efficient to help demonstrate that project first, you know, to spend less money on the demonstration than pay for the above-market funds, which are limited.

So, another rationale that our conversations with the investment community, the value of a power purchase agreement for an unproven technology is less than a PPA with a proven technology, even if, you know, this new project has a PPA, it's still not necessarily going to get the financing it needs to be built, because the technology isn't proven.

So, rather than committing the limited above-market funds for power purchase agreements with emerging technologies, we're encouraging the utilities to use ERP as a mechanism towards demonstrating and applying these technologies towards commercialization.

We also view ERP as an important mechanism to reach the 33 percent RPS by 2020 and the 2020 AB-32 goals. These statewide mandates have contributed to increased demand for renewable energy. We've seen a limited supply in California. And as a result of these factors, increasing prices.

We're also seeing competition from other states for renewable energy. They have their own RPS mandates. So we see ERP as a way to reduce this imbalance between supply and demand by increasing the supply of energy technologies. And as a result this could help alleviate pressure on renewable prices.

So, in order to insure these benefits by 2020 we've established three guiding principles for ERP. The first, projects must possess efficient renewable potential to address state renewable and climate change goals.

The second guiding principles, that projects must achieve commercialization at a competitive price within the 2020 timeframe.

And third, ERP must benefit California ratepayers through either developing technologies specific to California and the western region, or coordination between IOUs and other emerging technology programs to avoid duplication.

So, as I mentioned at the beginning, it's really important to us that we work together with PIER and that we coordinate with PIER so that we're not doing the same types of funding.

One thing we had recommended in the proposed decision was to do an investment, a renewable technology assessment report, to assess the gaps. And I was very excited when I saw on Gerry's presentation that you're already doing that. So, it's definitely a clear area where your research is going to help the utilities in reaching their goals.

And that's pretty much where we are right now with the emerging renewables resource program. It still needs to be voted on by the Commission. But we do have another program that the Commission has already approved, and that's the RD&D program for the California Solar Initiative.

That was approved last year and that is a $50 million budget until about 2017 to fund distributed solar technologies. And $10 million has already been allocated to the Helios project, to building the construction of the Helios project. And one of their goals is low-cost solar.

And one key distinction between ERP and the CSI program is ERP will focus on utility-scale renewables, while CSI focuses on solutions, demonstration of and enabling technologies for distributed solar.

So that's pretty much it. That's what we're doing now. And I'm happy to take any questions.

MR. SHIRMOHAMMADI: Jaclyn, this is Dariush Shirmohammadi with Oak Creek Energy. Do you have a presentation for what you just talked about? Do you have a written presentation?

MS. MARKS: I have notes, so I'm happy to share them with you afterwards.

MR. SHIRMOHAMMADI: I do appreciate that.

MR. DRACKER: Jaclyn, you might have explained this and I missed it, but is this plan to be an ongoing program. Will you do -- do you do solicitations every year, every other year? And what's the vision for how the funding will grow or stabilize or drop because of the budget crisis, or whatever?

MS. MARKS: Right, that's a great question. Right now this is presented as a two-year pilot program. And then after two years we will reevaluate the program to decide if there's a need for the program in the future, and what changes we should make to the program at that time.

MR. DRACKER: Okay.

MS. MARKS: Okay, thank you very much.

(Pause.)

MR. BRAUN: Our next presenter will be John Zack with AWS Truewind. We've had a good collaboration with John and his company in our R&D efforts in wind energy. And welcome John to the podium.

DR. ZACK: Thank you very much, Gerry. I'll be talking about the wind forecasting efforts to improve renewable penetration.

The outline of my presentation is that I'll start talking a little bit about the challenge of wind, and in general, geophysical renewable forecasting. And talk a little bit about the methods that we use to forecast time scales and how the needs challenges vary over different time scales. And then the operational use of forecasting right now, as well as some comments about the value of forecasting.

So, first, some comments about the fundamental need, which is to predict the power production of individual wind generation resources or aggregates of those resources over some desired time interval from a few minutes ahead to many hours and even days or weeks or months ahead. So there's a need over a wide variety of time scales and over different spatial scales from an individual resource out to aggregates of those resources.

And the meteorological problem corresponding to that is to predict the wind speed, direction and air density at each turbine location on each of the windfarms on the same time intervals of look-ahead periods.

And that translates into a huge challenge meteorologically because of the variations in wind and other atmospheric variables, as well, are driven by atmospheric features that originate and evolve and dissipate over a wide range of space and time scales under the control of a broad spectrum of physical processes.

And unfortunately, the current observational systems are able to measure only a small fraction of that variability. So we're handicapped with the fact that there's a huge range of processes going on and we can only observe a fraction of those. So we're quite at a disadvantage when we start out trying to forecast wind or solar or other atmospheric variables, as well.

So the way we meet the challenge, and this applies to the forecasting community, as a whole, though here I'm specifically depicting the ewind system, which is AWS Truewind forecasts, in the chart on the right there.

And this is composed of a combination of physical, also known as NWP or numerical weather prediction models and statistical models. And this is generally true of most forecast providers.

So the spectrum you see on the right, it is true not only of the Truewind system of most providers that provide renewable forecasts for solar or wind.

And there's a diverse set of influence, widely varying characteristics. You see those on the left, ranging from large-scale models run in government centers to regional weather data, to the data from the wind power facilities, themselves, and offsite met data.

And the importance of the specific models and data types vary with the look-ahead period. So, for a short-term forecast it's different in terms of what's important, what data, what models than it is for a day-ahead or many-day-ahead forecast.

And it's also important to realize that the different forecast providers vary in the way they use the data and the model. So some providers will rely on certain types of models more than others, and not even use certain types of models and rely totally on other types of models.

So I'm going to go through briefly the fundamental components of the system. One is, as I mentioned, these physical models which are the numerical weather prediction models. And they're based on differential equations for basic physical principles, conservation of mass, momentum, energy. These are close to what you may know as computational fluid dynamic models. And these are really CFD models and adapted for atmospheric purposes.

And these solved on a three-dimensional grid, and you have to start out by specifying the initial value of all the variables for each grid cell. On the right you see an example of an NWP model grid. And those are wind vectors over the Bay Area, San Francisco, and part of the central valley.

And these models simulate the evolution in the atmosphere over a 3-D volume. In order to start out that process you have to specify the value of temperature, pressure, winds, all the basic variables of each one of those cells. You don't have measurements in every cell. And that's the source of a lot of the uncertainty, is that each cell needs a value, but you only have measurements separated by maybe 50, 100, 200 kilometers. And it's in three dimensions, not just in the horizontal plane.

So you can appreciate this is a huge problem, there's a lot of uncertainty as you start out, not knowing the state of the atmosphere. And the models predict the state of the atmosphere from the initial state quite well if you know the initial state.

As you can see, because of the uncertainty to specify the initial values, you don't know the values of the initial state at every one of those grid cells.

So some forecast providers rely only on government-run physical models. Others run their own models. And the reason why you might run your own models, as we do at Truewind, is to optimize and model configurations for the forecasting of near-surface winds.

And the NWP run at government centers is optimized for temperature and precipitation forecasting for typical public applications. They're not designed for specific applications of near-surface wind forecasting. And they also can use higher horizontal vertical resolution on a three-dimensional grid. And the government models, because we can focus that resolution over a given area. We can -- simulations more frequently. We can incorporate data used by government models. And we can also execute a number of simulations that will have the sensitivity of the models for near-surface wind forecasting, something we call ensembles. And I'll mention a little bit more about that in a minute.

The other component of the statistical models, and many of you are familiar with these, these are empirical equations derived from some training sample. They have predictor data and then you derive a model. And there are many model-generating methods, linear, regression, neural networks. And we use a number of those within our forecast system, as do most forecast providers.

And the role of statistical models is to correct systematic errors in the NWP forecasts. So those statistical models, they don't have all the details of the surface of the earth and other physical processes exactly accurate, do accumulate some systematic errors, and the statistics are there to correct that.

And they also have the local processes that are smaller than the grid cells in the NWP model. And we can also incorporate additional observational data that was received after the last NWP model run, or that's not effectively included in those physical models.

And we can also combine met forecasts and power rating to power predictions directly, which is what we call an implicit plan output model which bring me to the third type of model that we use.

So there's three types of models that are prominent in these forecasting systems. The physical models or NWP models, adjust the NWP output. And then the plant output models, which are really the relationship of met variables to power production for specific wind generation resource.

So, once you have a met forecast, wind direction, wind speed and so on, you have to produce a power production forecast. You need that relationship.

And these models can be statistical or they can be physical, and they also can be implicit or explicit. In fact, you can have an actual planned output model or you can have a model that's implicit in your statistical models that I was referring to previously.

And the role of these plant output models is to model the facility scale variations in wind among determined sites. So, from one turbine to another, the wind varies on a minute-by-minute, hour-by-hour basis.

So the NWP models model on a larger scale flow of general conditions for the wind facility. Then the planned output model has to estimate how much the wind varies from one turbine to another, the turbine layout effects, the wind effects and other operational factors such as how many turbines are available, the turbine performance characteristics and so forth. So, that's the three main components of a forecast system.

And the fourth concept that comes into the forecasting process is the notion of forecast ensembles. So this is based on the idea that there's uncertainty present in any method due to the input data, the model type and the model configuration.

And the ensemble approach is to perturb the input data or model parameters within their range of uncertainty and produce a set of forecasts, an ensemble, if you will.

And the benefits are that an ensemble is often the best forecast, rather than any one individual forecast. And the spread of the ensemble provides a case-specific measure of a forecast uncertainty. So now we can look at one set, one time period, or one set of days in which the forecast may be more uncertain than in the others. And this is a way of estimating what that uncertainty is.

So, in terms of forecast products we have a number of forecast products produced. And the most direct is the deterministic predictions, which is the most likely megawatt production for a specific time interval. And this can be tuned to minimize the performance for a certain metric, such as the root mean square error or the mean absolute error.

So when you invent a deterministic

prediction it's minimizing some property of the forecast, you know, the mean absolute error or some statistical aspect. And when you tune it for one parameter, you may not hit optimal performance for a different parameter. That's something to keep in mind.

Now, if you have perfect deterministic forecasts, then you wouldn't need any other types of forecasts because you have the answer. Unfortunately, as you know, we don't get perfect deterministic forecasts in the actual megawatt value for any time interval you want.

And that leads to things like probablistic predictions. We have confidence bands. Our probability of exceedance value. There's a certain probability of exceeding a certain output for a certain period of time.

And then there is forecasts of events. The probability of a certain type of event occurring in a specific time window. And typically those events are large changes in power production up or down ramps, as they are referred to. So you can look at the probability of the event or the most likely values of the event parameters such as the amplitude of a ramp, or the duration of a ramp.

So that gives the operator a warning over a time window that he may have a certain event which may be different than the deterministic prediction, which tells you the most likely value of megawatt production.

And then there's the situational awareness products. So that if you use this in the forecast you can be aware of significant weather regimes or get a feeling for the geographic patterns of the way to get confidence in the forecast predictions that are explicitly made either deterministically or probablistically.

Now time scales are very important when it comes to both using and making forecasts. On the use side, in the short term, minutes-ahead, that's the regulation time scale where there's real-time dispatch decisions made for energy ancillary services. So that's one time scale of importance to users.

Hours-ahead, you know, one to six typically. Load-following issues. Short-term adequacy analysis occurs in that time scale. And we're talking about the next operating hour unit commitment. So, that's a different application of the forecasting process.

And day-ahead, talking about the day-ahead unit commitment. Ancillary services forecasting as opposed to dispatch. And then most trading activities occur by the market participants in the day-ahead timeframe.

And multiple days ahead we're talking about the long-term adequacy analysis.

And the forecasting problem also changes by time scale. On the short time scale, minutes ahead, we're talking about forecasting large eddies or turbulent mixing transactions from a turbulent regime, maybe, to a less turbulent regime.

These are very rapid and erratic processes that occur on very short time scales. And they're mostly not observed by the current sensor network. You don't have any way of knowing where these eddies are, or what the profiles of turbulent mixing are. So it's very difficult to make forecasts in this time scale. It's hard to beat a persistence forecast, which is what you have now. And it's often your best forecast for minutes ahead.

And we tried to improve upon that by

using what we call autoregressive trends. Basically saying what's been happening at the windplant over the last five minutes or ten minutes. And extrapolating those trends forward in time in some way, perhaps working in whatever, other weather, offsite weather data we might have.

And it would be helpful to have high-resolution three-dimensional data from remote sensing to help map these features that would help improve those forecasts.

On the hours-ahead timeframe, the problem's a little bit different. There's circulation features such as sea breezes, mountain-valley -- are larger. They're still rapidly changing and have short lifetimes. But they can be partially sensed with the current sensors. We can detect their existence, but not very much about their structure.

And we use a mix of all our regressive trends with offsite data. And the NWP starts to become more valuable here because now we can start to initialize all those grid cells on this scale. Remember on the minutes scale turbulence, we can't initialize the NWP model. We have no data on that timeframe.

And if we have three-dimensional data from remote sensing we can really improve the hours-ahead timeframe. Now, days ahead, the important -- systems here on the lows and highs, and you see the nightly news or in the newspaper; and these are slowing evolving features that have long lifetimes. They've been well observed with current sensor network.

And NWP does really well. As I mentioned before we use statistical adjustments that correct the system errors, but we're able to define the initial state. And on the day-ahead timeframe, numerical weather prediction models do quite well. Although we can always use more data in the data-sparse areas, such as here in California. Over the Pacific Ocean, a huge data-sparse area and affects the accuracy of the day-ahead forecasts and beyond.

So, in terms of forecast evaluation issues, the evaluation approach depends on the type of forecast, whether it's deterministic or probablistic; whether you're looking at hourly values or minute values or daily values. Or are you looking at events, ramps. So there's different types of forecasts, you have to evaluate them differently.

For a deterministic forecast standard metrics include the Bias, mean absolute error and root mean squared area, measures the overall size of the error in different ways. And focusing on maybe your smaller errors or bigger errors. But you're looking at the typical size of errors when you're evaluating deterministic forecast.

And you also look at error frequency distributions; say, how often do you make an error that's larger than say 20 percent of capacity, or some number that you might be interested in.

Now, probablistic forecasts are different. They're never wrong in the sense that you have an error for specific forecasts. So you can't get the error of a specific forecast probablistically. You have to look at the reliability. If you say there's an 80 percent chance of something happening, does it really happen 80 percent of the time. That's reliability.

And sharpness is the degree to which you can discriminate between events or values. As I say, there's a hundred percent chance that we'll have power from a wind plant, I'll be reliable, there will be power from the wind plant a hundred percent of the time, right. But that doesn't give you any sharpness to differentiate that you'll be able to differentiate between cases where you have lower power or higher power output. So the sharpness is the other aspect of a probablistic forecast.

Now event forecasts, the ones with a different approach, you have to look at the -- and it's deterministic -- a hit rate, a false alarm rate. If I say, in effect, it will occur, will it actually occur; how often; or will it not occur and be a false alarm. So there's a different way of evaluating the event-oriented forecast.

And we also must consider the objective of the forecast, that forecast can be optimized, as I mentioned before for specific metrics. So you should really evaluate a forecast based upon its objective. And also based upon what information's relevant to the user, you know. What's the user's cost function in the application of the forecast.

So, in terms of typical range of forecast accuracy, you see in the chart on the right, it's for an individual windfarm. The forecast time step of one hour. Size of the aggregate and the time scale does matter. And you will have forecast error typically increases very rapidly in the first few hours because of the accumulation of the error from all those small-scale features that we don't model very well, don't measure very well.

But then it tends to flatten out as you go after about six hours or so. You see the mean absolute error as a percent of capacity, levels off somewhere around 15 percent or so as you go past the 12-hour look-ahead point. And this is because in a day-ahead mode we do a pretty good job. As I mentioned, NWP models forecast quite well because they have the data, they can simulate the atmosphere on the large scale quite well.

So you don't accumulate error as rapidly after about, you know, 6 to 12 hours. It's a small scale, it's very hard to measure, very hard to predict with the tools that we have right now.

Now, there's always the issue of forecast comparison, what forecast is doing better, what methods are doing better. And comparisons are complicated by the fact that there's a lot of factors that affect the forecasts performed as beyond the merits of an individual forecast or individual method.

I listed a few of them here. I'm going to mention just a couple of them in a little bit more detail. The regional aggregation, the quality of the data from the wind plant.

So, in terms of regional aggregation, this is an example from the Alberta forecasting pilot project that ran from May of 07 to April of 08. There were three forecast providers, two from Europe and AWS Truewind.

We forecasted for 12 farms, for one- to 48-hour period ahead. And you'll see the mean -- number of mean square area on the right, here for look-ahead periods going from zero to 40 hours.

And the interesting thing is the topmost line, the darker blue, root mean square error for the windfarm average, which is about 50 megawatts per farm in this case.

And then the lighter blue line there is the regional average root mean square error for the forecast. There are four regions in this project, 158 megawatts per region on average.

And then the red line there is the system, the root mean square error. And you can see, because of the aggregation the regional day-ahead forecast is 15 to 20 percent lower than for the individual farms.

So you get a 20 percent improvement in your root mean square error just because you aggregated your regions. Now, 50 megawatts to about 158 megawatts.

Then you go to the systemwide in this case a little over 600 megawatts, you're 40 to 45 percent better than forecasting for individual farm. You haven't done anything differently. It's just because the random error for the individual farms, to the degree that they're not parlayed, it will offset each other.

So, this aggregation effect sometimes leads to confusion in evaluation of different forecasts. There was a group that went over to Spain to look at the Spanish TSO use of forecasting. And they came back and reported that the accuracy of their forecast system is phenomenal because they reported that there was about 5.5 percent root mean square error for 48-hour-ahead forecasting. You'll notice, quite a bit lower than what we were getting in Alberta.

And the reality of it is that that is

not so phenomenal because you have to consider that the Spanish system has about 15,000 megawatts installed, 575 windparks, average about 30 megawatts per park. And the peak generation is about 10,000 megawatts.

So when you look at the size and diversity of the system, you have a much lower mean square area. So if you're comparing what was done in a system like this comparing to say Alberta where you have a small system, a virtually individual farm, that the magnitude of errors are much different. So you have to keep that in mind.

Now, another factor that affects performance quite a bit and often beyond the control of the forecast is the availability of quality data of the wind generation resource.

This is an example from California. On the left is a reference wind generation resource; and on the right is one that's adjacent to that. So these are right next to each other. And one provides much higher quality data than the other. The one on the left has six met towers and reports availability pretty reliably.

On the right availability is more of an issue. You can see wind speed versus power there.

And there's a lot more spatter because there's only one met tower. And they weren't quite as reliable about reporting outages so you get a lot more spatter. Or as even wind speed, it's more uncertain what the power production will be.

You will have the annual MAE, mean absolute error. The one on the left, which has better data, remember these two are right next to each other, adjacent, see the same wind regime, all the forecast methods are the same here.

And you can see 11.3 percent annual mean absolute error for the better data provider. And for the other data provider it was not quite as good, 14.6 percent. So that's a difference of about 3.43 percent of capacity. That's over 30 percent difference in error relative to that 11.3 percent. Just because of the quality of data from the wind facility, itself.

Now, in terms of where we are on operational use. Forecasting in the U.S. right now. This is an overview of the use of forecasting by U.S. balancing authorities. So, California ISO using forecasts for their PIRP program, which was implemented in 2004, this is reused for market purposes only, not for grid operations up till now.

Then we deliver hourly forecasts for four- to ten-hours ahead for this program. And once per day day-ahead forecasts at 5:30 a.m. And there's an RFP process right now to expand the scope and use of the forecasting services. And the idea is to bring that into the grid operations procedure as we move forward here.

Now, ERCOT in Texas began operation of forecasting July of this year, about 30 days ago. And we are the forecast provider, and provide one- to 48-hour-ahead forecasts every hour there. And they are using it for the management of grid operations, but they just got started with that, so it's still in the shake-out period as to what do we do and how do we use these.

New York ISO also began, curiously enough, July 1st. And we're working with them to provide forecasts. And they have a slightly different mode. They get 15-minute forecasts for zero to eight hours out at 15-minute intervals. And they're updated every 15 minutes, and they're on 15-minute intervals. And they're twice per day, two calendar day-ahead forecasts. So 4:00 a.m. and 4:00 p.m. we have the two-day-ahead forecast. And the short-term forecast, one-hour-ahead timeframe, are used for grid management operations.

The Midwest ISO recently selected a forecast provider. They're going to go ahead with a centralized forecast system. We're not the provider there. I don't know all the details.

And PJM is in the process of a forecasting procurement. It plans to have an RFP out in the fourth quarter, and forecasting sometime in 09.

And Bonneville Power is also looking at forecasting options. Right now they get forecasts from individual plants. And each plant can decide how they forecast.

So, just a few words about the California ISO PIRP program. It's a voluntary program; resources can opt in or out hourly. In order to participate they have to pay a forecasting fee, which is currently 10 cents per megawatt hour. And they have to provide real-time data, according to the PIRP protocols. And they have to schedule to the PIRP next operating hour forecasts. It's a four-hour-ahead forecast.

And if you do that and you're part of

the program, there is a reduction in market price risk. There's also an exemption from some of your system management charges. And you also get an hour-ahead, a day-ahead forecast for other uses, as well.

And right now PIRP is only wind, although the processes and motion to include solar probably by 09. There's a whitepaper on the PIRP page of the California ISO website talking about the requirements for the solar aspect of PIRP.

So, in terms of the obvious question is the value of forecasting. How much is it worth, and it's a hard thing to quantify. It's still under debate.

Value comes from many different interconnected ways. There's savings from the efficient selection of generation mix. Maintaining grid reliability; market activities. And there has been some recent grid integration studies that have attempted to quantify cost savings here in California, as well as New York integration study. One done in Ireland.

And they all have pretty much the same flavor, which on this slide here, a couple of charts. This is a study that was done by GE with

AWS as a subcontractor. Considered four different scenarios. Two of them were for 2010, one 20 percent renewable energy and one with 33 percent.

The value of day-ahead forecasting was analyzed for both of those scenarios. And you can see charts on the right there which look at the reduction variable cost according to these scenarios. And they consider the day-ahead forecast and the variations in spot prices and fuel displacement.

And the bottomline is that the state-of-the-art forecast, according to this study, saved about 75 million a year in the 2010 -- scenario; that's the 20 percent. And then in the 33 percent renewable scenario, it was $175 million savings.

And a large fraction of potential savings from a perfect forecast can be realized right now. And if you look on the right there, the light yellow bars are the difference between what you get with a perfect forecast, in terms of savings, and the state-of-the-art forecast.

And while there's room for an additional savings, you can see that most of the savings, according to how this -- and the similar results were obtained in New York -- come from the current state-of-the-art forecast. And there's a lot of value right now. And a little bit more value would be realized by improving forecasts, but the value can be realized now.

And another important point here is that most of the savings are realized by nonwind generators. And the chart on the right there showing that solar, and I should say hydro and nuclear actually realize a lot of the savings when you have forecasts. Though, if you don't use forecasts, the chart at the right, the costs go up for the other generation resources.

So, finally, just a look to the future. How will forecasts improve? I have the top three listed there. Three and two relate to better use of models, either by improving the model or using cheaper computer power to make better use of those models. And, in general, models are ahead of the data right now. So the real improvement in forecasts is going to come from more and better data.

And a lot of this potential is on the zero-to-six-hour timeframe. Remember, I talked about we don't measure the small-scale features very well. We can't use NWP models very well on that timeframe.

So, as we get new remote sensing tools we'll be able to better measure the smaller scale features, and that will open the door to better zero to 6 hour ahead forecasts, which will be very valuable for that hour-ahead commitment, reliability, use of ancillary services.

So, I think that is where we're going to make major improvements over the next five years, enable better grid management with intermittent resources.

Now, of course, we also get better global data from satellite-based sensors. And that should help the day-ahead and beyond forecasts, as well. But probably not as much as the improvement we expect in that short-term period.

So, just to summarize here, as I said, the forecasts are made with a combination of physical and statistical models. And we use that to construct an ensemble forecast. And a composite is usually the best forecast. And dispersion or spread of that is an estimate of uncertainty.

The relative importance of different

methods and data types varies. Short-term, the long-term, different providers look at it differently, depending what data you have. And keep in mind that different parts of the forecast system are important under different circumstances.

And forecasts can be customized for specific objective. Remember the type of forecast, event versus deterministic, probablistic. And even if you have a deterministic forecast, you can optimize it for root mean square error, mean absolute error or other metrics.

And forecast performance varies due to many factors, makes comparisons difficult, especially casual ones. And the quality of data is an important factor. And centralized forecast systems have been implemented in several balancing authorities in the U.S.; and others are in the process of implementing them.

And grid integration studies certainly indicate that there are even for day-ahead forecasts the current state of the art has very large value. So we need to facilitate their use. That the use is coming along now, but in recent years they haven't been very heavily used. And I think that's starting to change now, and we'll be able to realize some of those savings that the grid integration studies estimate.

Thank you.

MR. BRAUN: Thank you, John. I think we'll hold questions until the period at the end.

I'd like to introduce Ray Dracker from Solar Millennium. And Ray will be giving us an overview of thermal energy storage and how that would work as an enabling technology with solar thermal electric.

MR. DRACKER: Thanks, Gerry.

(Pause.)

MR. GRAVELY: In the interest of time we could take a couple questions, if you want, now (inaudible). So why don't we, since we have a few minutes, we're going to go ahead and break, but I thought you might suggest to when. John, do you want to come back just a second in case there are a couple questions.

(Pause.)

MR. GRAVELY: So there's a mike there. Are there any questions at all while we're doing on the presentation for John? You can use the mike right there if you don't mind, John.

DR. SCHAINKER: Thank you for your excellent presentation. Since we have a few minutes I'm curious if your company or yourself looked at this Texas outage that happened -- not outage, but this wind event February 26th 08. And was there any predictions made of that with your software before or after to see what would have -- if the predictions -- just to throw out a question. I just thought maybe you had some insights that other people don't have on that.

DR. ZACK: Actually we have looked at it quite extensively. At the time we were providing forecasts to ERCOT in a test mode, and they weren't being used anywhere within the ERCOT system, but they were being delivered.

So we actually had a set of real-time forecasts that were there. And it turned out that they performed quite well. In fact, we compiled a report if anybody was interested in it. So, the report with only public information. So I can send it to anybody. It's really a (inaudible) Truewind internal report that we made available to ERCOT, as well as other people who were interested in that event.

And what had happened was ERCOT day-ahead unit schedules over-estimated the amount of power output that was projected for that time period. It happened about 6:00 p.m., I think, 6:40, on February 26th.

DR. SCHAINKER: Over-estimated wind generation.

DR. ZACK: Over, yeah, I think they estimated about 1000 megawatts in that period of production. And it came in around 300 or so. So there was that, of course, you know, they had other reserves available. And the real problem came in that the other reserves did not live up to their commitment.

So had everything in the non-wind world went according to plan, so actually the reliability issues were in the non-wind part of the system. And that's why they got into the difficulty they did.

Now, true, the unit scheduling of the wind plants over-estimated the amount of production, but only by about 700 megawatts, which is not that big a deal, you know, in what they normally have to deal with there.

But actually our forecasts, we give them two different types of forecasts, most probable value and 80 percent of probability of exceedance value.

And the production during that whole period was actually between those two values. Between the 80 percent number and the most probable.

So, actually they would have had a very good idea of what was happening; it was a very predictable event. And the reason why they didn't have an idea is because they didn't have an operational forecasting system. And the individual resources do a variety of things such as some of them submit yesterday's production as today's schedule or tomorrow's schedule.

And there's no uniformity and there's no enforcement of quality there, which is why they've gone to a centralized system.

DR. SCHAINKER: Okay, thank you. I just thought I'd ask a question --

MR. DRACKER: One other quick question. Everything you talked about for wind is going to be needed for solar. It's going to be much easier to do for solar, but it's all going to be needed. Is anyone doing anything about it? Is Cal-ISO even thinking about that for solar?

DR. ZACK: Well, the PIRP will be expanded to solar probably in 09. And, as I mentioned, that forecast system with the NWP models, the statistics -- NWP models put out solar forecasts and they can be adjusted.

So, everything there applies to solar being easily adapted. You can also do ocean-wave forecasting if you needed that.

MR. DRACKER: Okay. I'm Ray Dracker; I work for Solar Millennium. Solar Millennium is a solar powered development company, as well as a solar systems engineering company.

And so through the development company we do a lot of engagement with the market and our customers. And the market and our customers are the large southwest U.S. utilities and the control area operators like Cal-ISO and the like.

And so we're trying to understand what those entities need and want. And then we turn around to our systems engineering company and say, well, how can we design systems that can give the market what it wants.

And so that kind of gets to exactly the point of this workshop and this particular talk.

And that is what can be done to integrate thermal energy storage with concentrating solar thermal power to provide something more valuable to the electric grid.

Just another tiny bit of background. After the second oil shock in 1977, the U.S. Government, under the auspices of the Energy Research and Development Agency, launched a huge renewable energy program. And I believe the solar thermal program, as it was known then, was maybe the largest of everything, bigger than PV, bigger than wind, bigger than biomass and geothermal.

At the time there was no independent power industry, there was no QFs, there was no PURPA. And so the electric industry were the utilities. And so there was a big effort to try to see what it would mean -- what should solar thermal power look like from the utility/user perspective.

And one of the reasons why it was an attractive technology was because thermal energy storage could be integrated and provide the kind of additional value that we're all talking about today.

So, a lot of the ideas I'm going to talk about for the next 25 minutes were thought of 30 years ago. And there's not a whole lot new here. We've made some progress on commercializing this stuff, maybe not nearly as much as you'd like over 30 years. But, anyway, all these ideas are 30 years-plus old.

So how does thermal storage work with concentrating solar thermal power. What are the ways that -- what are the physical ways that you do thermal energy storage. And what are the benefits. So that's what I'm going to try to cover quite quickly here.

Here is a quick schematic of a solar power plant without storage. This kind of has a little cartoon that looks like a solar trough. My company is doing many different solar technologies. The one we're focused on commercially right now is solar trough technology. But I'm going to try to make this presentation cover all the different technologies.

But whether this is a solar trough and that heat exchanger in the middle is an oil-to-water heat exchanger, or if this is a nitrate salt sensor receiver and that heat exchanger is a salt-to-water heat exchanger, or if the thing on the left is a parabolic dish collector with a hydrogen heat pipe and a Sterling engine on the right side, or even if it's a photovoltaic array with an invertor, it's all the same.

The thing runs, what I call run-of-sun. When the sun's above cut in insolation, the thing turns on. It operates kind of proportionally to how much additional solar energy you put in. And when the solar energy goes away, it turns off. So that's kind of the way all run-of-sun solar power systems work.

And, of course, you know, as we discussed just previously with the challenges of wind, a utility system control guy would prefer to not have it that way.

Here is a schematic of, again I show a solar trough system, here's the schematic of a power system with integrated thermal energy storage. This is a two-tank indirect system. And, again, this is nitrate salt. It could be any number of different fluids.

But basically the heat transfer fluid in the solar collector is a synthetic oil. And that energy is either sent to a steam generation system to make electric power, or sent to a salt heat exchanger to store the thermal energy in a hot salt tank. And then the hot salt tank can discharge and make steam when you want to make steam off your storage system.

I am not an expert on all of these things. Again, these ideas have been worked on for 30 years. Sandia National Laboratories, DLR in Germany, a lot of work going on in southern Spain at the PSA. And then NREL has most recently re-initiated a storage program.

But there's any number of ways to do this. One is to store the energy in a single phase liquid. You can use two-tank indirect storage, as I just indicated. Or direct storage if your heat transfer fluid is the same as your storage media. You could use a thermocline which eliminates a tank but creates other complications. The liquids, for the most part, have been looked at or been salts and synthetic oils.

Also you can store thermal energy in a phase-change medium. There's different materials to do that. The benefits of that, of course, you store some of the energy as latent heat as opposed to sensible heat. And then if you're working off of a steam rankin cycle, you've got to boil water.

And sometimes you can match things up thermodynamically a little better.

And then lastly there's the potential use of concrete, which is a fairly inexpensive mass storage media. Obviously you've got to transfer the heat into the concrete and then transfer it back out. This is show promise. DLR in Germany and Spain is working on this concept the hardest.

Our company has been focused on using nitrate salt storage. General logistic, couple of shots here of engineering drawings. Here's just the layout of a hot tank and a cold tank. And the current salts we're working on have very high freezing temperatures, which is a bad thing. We're working on salts with lower freezing temperatures.

But basically we're in the process right now of melting salt in our Andasol-1 project. Once that melts, it's going to stay liquid for 30 years hopefully. If it freezes we're in big trouble.

We mount all the heat exchangers and the pumps above the tank so, you know, if something goes wrong you just gravity drain it into a tank and then you go from there.

Another illustration there of what the thing looks like. And here's some pictures of the thing in construction. These are all built now; and, again, we're in the process of melting salt. These big white buildings are where all the salt's stored in its solid form before we start the melt.

So, we're building this on a large scale. And here's just some of the design parameters. Again, two tank, cold tank temperatures about 300 C, the hot tank about just under 400. And, again, we've very high freezing temperature of 223 degrees C.

You can imagine it's a challenge to keep something above that temperature for 30 years straight. But we will do it.

The benefits of just direct integration of thermal energy storage, as opposed to going to electric energy storage is sort of that turn-around efficiency of 95 percent. Ninety-five percent of the thermal energy we put in we get back out as thermal energy. And, of course, we convert that thermal energy to electricity, about a 40 percent conversion efficiency, 35 to 40 percent.

Why, again, molten salts? We based the design of our salt system on the Solar Two design that was built for central receiver plant in the early -- designed in the early 90s and built in the early and mid 90s.

It's a mixture of sodium and potassium nitrate. And can't quite see that entire diagram, but you try to mix those in a way that gives you the mix of thermodynamic properties you're working toward. And one of the desires is, again, to have a low freezing temperature.

Again, molten salts got high specific heat relative to material costs. Low degradation rate at the temperatures we use it at. And it's environmentally benign. If it freezes -- it drops on the ground and freezes, you shovel it up and you can use it as fertilizer.

Molten salts have been used as a thermal energy storage medium in many industries for many decades. And we've been, you know, the industry, the solar industry's been working to lean on that body of knowledge.

The Andasol-1 plant was financed on a totally non-recourse debt basis. And so that kind of tells you the confidence level the banks have that this is a commercially viable technology.

Again, a lot of applications in the process industry. This graphic's courtesy of Bertrams Heatec, which supplies these systems on a package basis. They've been working with us on several of our projects, supplying components and system design.

Here's a brief history of how nitrate salt or molten salt's been evaluated in the solar business. And this is, you know, cross, you know, three or four continents here. In Japan in the early 80s and France, here in the U.S. And most recently the Italians are doing a lot of good work on the use of nitrate salt for solar power.

A few people have asked me, you know, right now the solar thermal business, or the concentrating solar power business is booming in Spain. And it's because they have very high feed-in tariffs; tariffs that would be unacceptably high even in states that have the aggressive greenhouse gas targets that we have here in California.

So, people ask me, well, you know, how do you make stuff work here in the U.S. And the way you make it work is you make it bigger.

There's a 50 megawatt limit in Spain. And it would be tough for us to make a 50 megawatt projects that can only be viable here in the U.S. So we're making the projects bigger. And then if you're going to integrate thermal energy storage, the storage has to be that much bigger.

As many of you know, there's two elements to a storage system designed as the power. There's the energy and the power. And it's relatively inexpensive to make the energy bigger. You just add more tanks and more salt, and it's kind of a hassle but it's easily do-able.

But if you're trying to charge and discharge at the electric equivalent of 250 megawatts, you can imagine the quantities of pumps and heat exchangers you have for all of that.

So, right now Solar Millennium, as well as Abengoa, and maybe others, Solar Reserve possibly with their power-tower technologies, looking at very large energy storage systems for the U.S. market. As much, you know, 3000 and 4000 megawatt hours thermal storage systems are now being designed for the U.S. market.

And, again, some engineering challenges. Also, we're creating a demand for this salt that is many times what the historical world supply chain has been dealing with. So that's another challenge, as well.

Here's just a chart from DLR on the different -- on why the -- what are the figures of merit in choosing a energy storage medium. Obviously you're trying to store the most energy with the least amount of mass.

But then have other characteristics that match up with what your temperature needs are. You know, they have to match with the solar heat temperature regimes as well as the power cycle temperature regimes.

Again, I mentioned earlier, phase change materials, benefit from the latent heat aspect of them. They're still very developmental, but some day will become available. They're a good fit for direct -- DSG stands for direct steam generation. I don't want to make a treatise on the different CSP options.

We are working on a direct steam generation solar trough. Several companies are working on direct steam generation central receiver technology, BrightSource and others. And a few folks are working on direct steam generation, Linear Fresnel, Ausra. And this is a technology that works with -- that would be as good fit for all three of those technologies.

Again, cement storage, possibility for very low cost. Could be built in modules. Best for sensible heat, but I'm about to show you another diagram that's counter to that. Still developmental, but I think someday reasonably soon could become viable.

Here's the use of a cascaded concrete storage system for steam generation. And you can see, you know, you try to match up the temperature regimes with temperature profiles if you're preheating your boiling and you're superheating.

So, why do all of this? And, again, the idea is to make the solar energy more valuable for the grid, for the utility consumer.

One potential use of storage is to increase the annual capacity factor of the plant. that's how storage is being used at Andasol. And under this application of storage, and this only, it's also possible to make the levelized cost of the electricity lower. All the other uses of storage I'm going to talk about will raise the levelized cost.

But if you do it for this, clearly what you're doing is you're getting better acid utilization of your power block, which, you know, when you're doing all the math, can result in lower electricity costs out of the plant.

But it's also possible to use the storage to concentrate or shift the solar energy collected to electric power during peak periods. That allows you to ride through transient weather conditions, which we can spend hours talking about that. I'll take two minutes to talk about it.

It can even out, and you can maybe deliver the electric output in blocks, if that's desirable to the utility customer.

And lastly, it can give solar power capacity value, and this has been a bone of contention between my company, on a friendly basis, for the California utilities, but we'd love to get capacity payments for our solar power plants.

Here's some charts that are a little bit hard to follow when you first look at them. Maybe some of you have seen them before. But let me try to walk you through this, because this shows how storage can be used, and kind of then why would you do it and how it would be more valuable to the utility.

On this chart, I don't have uniform color coding. I'm going to show three charts like this, so bear with me.

So the blue line is the solar radiation. And if someone's looking closely this is the solar radiation in a place where there is daylight savings time, the peak happens at 13, not 12. And by the way, this is different in Arizona than in California.

So the orange line is the heat collected by the solar field. And that's -- the solar field's working run-of-sun without a doubt, so the heat collected by the solar field matches kind of the DNI that you're getting at your power plant site.

And this is a plant designed to shift morning solar energy to evening electricity. I'm lousy at using these.

(Pause.)

MR. DRACKER: So, let me do it the old fashioned way -- I have to speak into a microphone. This plant, you can see the sun comes up at 6:00 a.m. We don't make electricity till noon, so what do you do with the energy load. All morning we're putting it into storage.

And then at noon we shut the storage charge down and use the energy strictly for electricity production. So we show magically all that happening instantaneously. Obviously there's a lot of inertia in your pumps. But you can kind of do things about that crisply if you know what you're doing.

So we stop the storage charge at noon and bring the steam turbine up to full load. And then the sun starts setting on this day at approximately 7:00 p.m. And so at 5:00 p.m., we start discharging our storage system.

The red line represents the power production, so you can see that we're operating at, you know, 250 megawatts starting at noon. The sun sets at about 6:30, 7:00 p.m., and we drop only the electricity production a little bit and run the plant till 11:00 at night.

So that's one way to use storage. To shift morning solar energy to evening electricity production.

Another way to do it, and this is the way we're doing it at Andasol. And this is he only way to maybe make levelized electricity price drop. And we can do this in large plants.

And this is where you have a very large solar field. You start up you power block as soon as the sun rises. And then shortly after you get your power block with full load, you start charging the storage system.

So, here the sunshine is the blue line. I apologize for the sun comes up. The red line's our power block. You bring the power block quickly to 250 megawatts. And then we shut the power block up to 250 megawatts. The solar field's got excess steam generating capacity. And so we start charging the storage.

And then -- so we can -- so the sun starts setting at, again, the sun starts setting at 6:30 or so. You start -- you see there's some overlap here, but we start -- we ready the storage system for discharge. And basically this allows us to hold 250 megawatts again till 10:00 or 11:00 at night.

So this is a capacity extender version. Again, maybe can make levelized lower costs of electricity.

The last way is to concentrate all of

the energy production during a narrow band, you know, on a block in maybe peak period, if anyone from Southern Cal Edison is in the audience they may recognize the profile here that's being targeted.

But here, again, the blue line is the DNI, and the red line is the solar field collection; the orange line is the electricity production. Here we're storing -- we're not making any electricity in the morning at sunrise; we're strictly storing energy.

And after 6:00 p.m. we're not making electricity, we're strictly storing energy. And everywhere in between we're making actually more electric power than the solar field could sustain on an instantaneous basis.

So, here the solar multiple is less than 1 for any solar engineers in the audience. This certainly would have a much higher levelized electricity cost. But you could see that if, you know, you have a TOD factor that's, you know, 3, 3.5-to-1, morning to afternoon, you might want to do something like this.

So, these are the ways. Now, the other thing this does is provides a reliable block of capacity in theory during the time the utility needs it the most. And we'd love to get $100, $150 bucks a kilowatt year for the capacity on top of a nice energy payment. Right now that's not an interest in California doing that. So, again, you know, from a planning perspective, you know, what makes sense, or what it wants to do.

A few other things. The California utilities have different, you know, the three big IOUs have different, slightly different TOD periods and factors from one another. And so obviously you'd customize your solar power plant slightly differently to serve each of those.

SMUD has a more severe needle peak than any of them. And LADWP is sitting largely on the coast, so it doesn't have a huge air conditioning load per capita. So, you know, what we try to do is, you know, have a system design that would custom fit any individual utility.

So I'm not sure if the target is the Cal-ISO integrated system or any specific utility. But we're trying to adjust to all that.

Lastly, the other thing that storage does is it allows you to ride through a cloud transient. And there's benefit to utility grid to that. Obviously you don't want a 250 megawatt or hopefully, you know, an aggregate of several thousand megawatts, you know, going offline suddenly when a big monsoon cloud hits.

This is not a big issue in California, although it's some. In Phoenix they get really bad monsoon clouds summer afternoons, July and August. So the utilities really asked us to figure out how to use storage to ride through cloud transients. Because they have no dropoff in air conditioning load when these monsoons hit. If anything, people crank them up a little more.

In Blythe, in southwest California you do see some of this. You know, the last three weeks we've had a lot of rainstorms in Palm Springs and stuff. A place like Ridgecrest gets a little less. And probably Carrisa Plains almost never sees a monsoon cloud.

So, I don't know how big a deal this is for California. We've looked at this a lot. And so if that becomes important, we're happy to study it more with everybody.

So, in general, thermal storage is used for, you know, to help diurnally. It's not going to help with weekly or seasonal storage by any means.

You could build one hour of storage, you could build 12 or 15 hours of storage. The sweet spot seems to be, you know, three to six full load hours of storage. And that seems to provide most of the value.

At six full load hours of storage we maybe can make the LEC lower if you want the capacity extender. But we can also do these really nice customized things. I think these will mostly be built where you begin to assign capacity value.

We haven't talked to any California utilities, but we have talked to Arizona and Nevada utilities about building plants that can provide reliable blocks that would result in the utilities not buying a peaking gas turbine. And so other states are thinking about that. I've no idea where we are here with that kind of thought.

But we do think we can make solar reliable enough through thermal -- integration of thermal energy storage to forego the deployment of peaking gas turbines.

So, anyway, that's that. Any questions? Two minutes to lunch. Ready to go to lunch?

MR. GRAVELY: Yeah, go ahead, we've time for a few questions.

DR. SCHAINKER: There's a microphone.

MR. KIBRYA: This is Golam from the Energy Commission. I have two parts to my question.

Knowing that, of course we know that there a lot of -- CSB and PPA is being signed in California and other parts of the country. And I imagine a lot of this PPAs and contracts are thinking of putting storage.

Now, knowing the price of salt has gone up more than 100 percent in the last year or so, if you could comment on how this price of salt is going to affect, first of all, LCOE of this contracts that we anticipate coming online in the future.

Second part of the question is, you know, what other technologies are really being looked at as opposed to salt, to provide the TES, the thermal energy storage? We know the salt has been the most proven from solar to deployment. But I'm sure there are a lot of other technologies that people are looking at for thermal energy storage.

If you could comment on what are the most prospective ones.

MR. DRACKER: Well, I showed a few of them earlier, the concrete storage, the phase change. I think there are other solar companies here in California that are looking at other innovative things that they haven't shared with everybody.

There are some innovative ways to doing some modest, on an energy basis, amounts of energy storage with steam, water steam.

But I think the most promising is probably some version of the concrete. And, you know, again, DLR has been focusing on that. There had been work done here, but there's not much going on here in the U.S.

So, you're right, the price of salt's doubled. But, you know, we've looked at things and I think it's -- we think, and slash, hope it's a supply chain issue, not a fundamental. If you just look at the raw materials that go into, in theory the demand that's been created should be able to bring supplies back up to a level that will drop prices down to whatever, not super-profit prices or whatever the salt guys are getting right now.

One other tidbit is we're looking at a low melting temperature salt, low freezing temperature salt, below 100 C, below most importantly below the boiling temperature of water, which has some, you know, below 100 C.

But it requires lithium. And plug-in hybrids are creating a huge demand for lithium. So, you know, unfortunately we're kind of bit there.

But, again, you look at the fundamentals of, you know, lithium supply. If the market responds, it actually might, the plug-in hybrids might create a huge lithium supply infrastructure that will decrease the cost of lithium ten years from now. But right now lithium's -- so this is all critical stuff.

Yes, it's impacting the economics. There are not huge margins in these deals. And you double the salt price and it's going to mess up the economics of the project.

We had several actually the -- I mentioned one of the drivers of the use of storage is the ratio of the afternoon TOD factor compared to the morning TOD factor. And for one major utility that ratio dropped this past year. It might have dropped to make storage economically viable to not economically viable. And when you roll in, you know, salt prices.

So every day these little things affect the market. The short answer to your question, though, I think the concrete has the most near term for this, you know, five-, six-, seven-hour of storage that would be applicable to many of the technologies.

MR. KIBRYA: Thank you.

MR. GRAVELY: One final question if you wanted to ask, go ahead.

MR. WHITE: Oh, I have to pick between my two questions?

(Laughter.)

MR. WHITE: So I just pick my better question. Just on retrofitability, can you say something about the feasibility and cost if the storage was to be retrofitted into the design of a plant, and not factored into the original design?

MR. DRACKER: Yeah. This can be done, although when you match up the size of the power block, the size of the solar field and the size of the storage system, in theory their size, relative to one another, to provide some sort of optimal value proposition for how you're going to operate the plant.

But fundamentally you can. For instance, the modular Solar One was built without storage. They could add storage to that plant. It is possible.

You can also -- any of the solar technologies are somewhat modular, so you could add it in an increment of solar. You could keep your power block, add an increment of solar field, add a storage system and have something that's optimized.

So, the short answer is yes. You can add storage to a plant that was not originally built with storage.

MR. GRAVELY: Well, thank you, everybody. We will reconvene here at 1:30 and go with the panels for the afternoon. And we'll have some more time in the afternoon to talk to all the speakers that'll be around for questions and answers.

(Whereupon, at 12:33 p.m., the workshop was adjourned, to reconvene at 1:30 p.m., this same day.)

AFTERNOON SESSION

1:38 p.m.

MR. GRAVELY: We do have a pretty full afternoon. And we do have some time at the end for some discussions, so we'll do that.

So, what I'd like to do now is we have basically two panel sessions this afternoon. It'll be mostly presentation with some joint discussions. Both panels are at the table here so there'll be opportunity to ask questions as we go forward, and I encourage that in the afternoon session here.

And so we're going to start off with kind of the way we did in the morning, we'll do a little bit of the grid side of the world, and then we'll go to the renewables side of the world. And then we'll have some general discussions on the whole day's workshop.

And so with that I'm going to introduce Dr. Robert Schainker, who is going to talk us about energy storage, and the ability of storage to help penetration of renewables.

DR. SCHAINKER: Thank you very much, Mike, I really appreciate it. Thank you for inviting me. We don't have a full house yet, but

I'm sure a few people will walk in after lunch.

I've decided to wake everybody up a little bit because this is a tough position, right after lunch. Most people are trying to go to sleep right now. So I thought I'd take a little different tactic.

My tactic is to assume that I've just given this presentation and I'm going to ask questions. And likely you may have some questions on energy storage. And just ask them. I won't answer them because I'll use the presentation to answer them, as appropriate. Hopefully I'll find something in a slide that'll help me answer your questions.

So, are there any particular questions on energy storage? For instance, cost, or performance, or what is SMES, or what is CAES. Anybody have any burning questions that you want to ask me? I know you're digesting your food, but I thought I'd give you guys an opportunity. I'll ask you again later. Looks like nobody has any questions. Okay. Either that's because I'm such a good speaker, which I doubt, or --

MR. BROWN: I have one.

DR. SCHAINKER: Well, good.

MR. BROWN: We've been trying to get storage into the grid both at the high voltage and low voltage for many many years, because it would solve so many problems. It essentially adds a temporal value to control of power flow.

And yet it just hasn't happened other than some pumped hydro which was almost an after-thought in many cases. Are you going to answer why that it hasn't, despite the fact there's a strong desire for it?

DR. SCHAINKER: I think your question is so good that I will answer your question. I'll give some of the answer right now.

In fact, there's a story -- there's probably an answer appropriate to every one of the various storage technologies, but in general, in my view, and I'm not speaking for everybody or even necessarily EPRI, where I'm from, E-P-R-I.

This country, our dear United States of America, has been spoiled for many many many years with very very inexpensive fuel. And our fuel prices ten years ago natural gas was $1.50, $2.00 a million Btu. Today it's $10 to $14 a million Btu. Oil in those days was oh, $4 a barrel; and now it's, you know, $135 to $140 a barrel.

And when we had such low prices in fuel most people did not think of energy storage, per se. They thought of building combined cycle gas turbines just generation. And I think that's the dominant reason, it was an economic reason.

It wasn't necessarily because people were ignorant of the technologies, per se, although there was a lot of development that's needed in some of these technologies since then.

So the price of fuel has increased and I think that's why I'm standing here, in some respect. And then the other issue, of course, is renewables, which is the subject of this meeting.

And renewables, one its challenges is its intermittency depending upon the type of renewable technology you're looking at. And energy storage is an obvious option to think about. But the costs have to be considered seriously before you would install them. So I think that's basically the answer to your question.

By the way, on pumped hydro, the first pumped hydro plant in the United States was built in 1928. And it really wasn't an after-thought. Pumped hydro was actually a very seriously debated and economically analyzed technology. Americans were actually probably second or third in line. The Europeans, particularly Swiss, beat us to it.

And a lot of pumped hydro plants were built throughout the world. In this country only about 2.5 percent of all generation is pumped hydro. But virtually, in reality, most of all storage in this country is pumped hydro.

Can there be new pumped hydro, that's debatable, based on the current prices. But pumped hydro got built even before nuclear got into the grid. And then a bunch of nuclear was advent in the early days of nuclear. A lot of pumped hydro plants were built because of nuclear.

Any other questions? Those that just walked in, I switched gears. I'm asking you for questions now, and then I'll address -- then I'll give you my presentation and you can ask some more questions later.

Okay. For those who aren't familiar, these little icons in this presentation show four storage technologies. There's a few that aren't on this list, but this is what a superconducting magnetic energy storage coil looks like, SMES, as referred to earlier by Raymond.

And it's the only storage technology that stores electricity in the form of electricity. In this case it's dc electricity. And as a consequence, it's round-trip efficiency is in the 95 percent range.

This icon in the upper right-hand corner is a battery. We all have them in our cars and our flashlights. And there's a lot of stored energy throughout the country in various batteries. And there are a few, I'd say around the world there's probably 100 or so energy storage plants for electric utility applications.

Here, this icon in the lower right-hand corner is pumped hydroelectric, although you could think of it as a hydro plant. But there's a reservoir above and a reservoir below.

And the icon in the left, lower left corner, is compressed air energy storage. It's an interesting technology. I'll chat about it a little bit later, because EPRI is going to be building some utility support, two demonstration units using an advanced design.

But it's a storage technology that uses not only electricity in and out, it uses fuel, as well, during the generation phase for the current design. So it's what I would call like a plug-in hybrid vehicle. It uses fuel and electricity for energy storage.

Okay, with that let me get into the presentation. Historical perspective, pumped hydro has been around, like I said, since 1928. Interestingly enough in other parts of the world, mainly in Japan, Switzerland, Germany, France, Spain, Italy you'll find the amount of pumped hydro in relation to their overall generation capacity is in the range of 5 to 15 percent. They have much more energy storage as a percentage of their generation mix than the U.S., which is about 2.5 percent.

And I find that raises a question, because I looked into that and all I could figure out is that the rest of the western world, they actually do their economic planning studies on a longer planning horizon than the U.S. does. We're very short-term thinkers.

And most of the rest of the world, when they do generation planning, and energy storage planning, and they look at pumped hydro, they think long term. And fortunately for them, if they own any pumped hydro plants, that's been a very big cash cow for them.

And any of the few utilities that own pumped hydro in this country made a lot of money on existing plants. It's very difficult to justify new plants today, but the plants that were built in the 60s and 70s, 80s, made a lot of money.

There's been a number of battery plants. There was a big battery plant in Southern Cal Edison, the world's largest battery went into commercial operation in '88. It was a 10 megawatt, four-hour battery in Chino, not too far where there was an earthquake earlier this week.

There's a compressed air plant in Alabama called the MacIntosh Plant. It was built in 1990 -- 88, 89, 90, went into operation in 91. It's a 110 megawatt plant, 26 hours of storage.

One of the first supercapacitors ever built was built and demonstrated at an EPRI laboratory called PEAC in 2002. And there's a flywheel that went into operation on a utility grid in 2003 at New York Power Authority, one of the first ones in the country on the grid.

And American Electric Power built the first sodium sulfur battery in 2006. It was a 500 kW one-hour sodium sulfur battery. Now they're building, I would say, one- and five-megawatt six or seven hour batteries at AEP, sodium sulfur.

Another historical perspective, many people in the utility environment just could not analyze the benefits of energy storage until some codes were developed. And the first chronologically based code to really successfully analyze energy storage, no matter what type of plant, was a code called DynaStore and Dynamics. In fact it was built at EPRI and it's still being used by utilities and EPRI.

Back in 03 EPRI published a handbook on energy storage. It's still a very good resource. DOE gave us a little bit of money and we put their name on the title. So, it's a handbook. Basically you find out about any one of these storage technologies in great detail.

Starting in 04, PIER, through the California Energy Commission did a lot of field trials successfully here on energy storage. Very very important to the country. DOE got involved in some of those field trials, as well.

There were newer batteries at AEP, a big nickel cadmium battery in Alaska. Another flywheel system, TVA built some supercaps and so-called FACTS technologies, combining a flexible ac transmission system with a supercapacitor.

HECO built the first supercapacitor for a wind system. This was about five years ago. Unfortunately, there was an earth movement, an earthquake right underneath the facility about a year after they finished it, and it destroyed the facility. But it did work when it was running.

PG&E others, with CEC help, built zinc bromine battery. So there's been a lot of activities in energy storage. Mostly for demonstration purposes and some commercial plants.

Recently, compressed air energy storage has a new design over and above what was built in Alabama. Remember, the Alabama plant up here was 110 megawatts, 26 hours. EPRI's going to be funding a fairly large program to build two plants, one a 300 megawatt, 10-hour compressed air plant, and one using an underground air storage reservoir. And then one of 15 megawatt, 2-hour system with an above-ground air storage tank or piping system.

And there's been lithium ion batteries, relatively small, but they're coming. Other flywheels; familiar with Beacon's flywheel systems for frequency regulation. Other supercaps for power quality and -- control. So there's a lot going on in the energy storage area.

In line with what Gerry Braun said earlier, there is really three insights that I think if somebody studies energy storage you need to really walk away with.

And one of the insights is right on with what Gerry Braun said earlier, storage plants really fall into three categories. What we call baseload storage plants like pumped hydro and compressed air that have lots of hours of storage.

Intermediate type storage plants that may only have two to three, four hours of storage. Similar to zinc-bromine, some sodium sulfur, some lithium ion.

And then what I would call peaking energy storage plants that are really suited for seconds or minutes of storage. They're just not economically attractive for long hours of storage.

And this metaphor of peak, intermediate and baseload, likewise for renewables, applies to energy storage technologies. And it really comes down to the economics. And I'll just shed some light on exactly why that happens in one of my slides a little later.

Another insight is that when EPRI worked with utilities, Alabama Co-op and others, Southern Cal Edison is an example on batteries, we found out that the dynamic benefits, the rapid response capability of storage technologies being factors of 10 to 100 better than fossil plants, actually provided five to ten times more economic value than their so-called arbitrage or load leveling benefits.

So, yes, people look at arbitrage, you know, buy low, sell high. But, in fact, the economic benefits are much greater if you quantify the rapid dynamic capability of these plants.

For instance, pumped hydro has minute-to-minute ramp rates, you know; 50 percent is nameplate capacity in literally a couple minutes. Whereas a coal plant may only have 10 percent of its ramp capability in an hour, or maybe 30 minutes.

So you really got to do some very detailed analysis to look at the dynamics benefits. If you do that, you'll find a lot of good value for that type of duty.

Third insight is that when you quantify the benefits of energy storage we have found over and over again not one specific benefit will sell the plant. You actually have to add and combine their load leveling benefits, the dynamic benefits together. If you can't calculate all these benefits, then you can find the benefit/cost ratio for purchasing and installing a plant is positive.

If you just look at one of the benefits you generally won't be able to justify the plant. So you really got to go into the energy storage analysis with your eyes open to these three insights.

Now, that's the bulk of what really I wanted to tell you, but I'll show you some other details to sort of underscore some of those three insights that I just chatted about.

Energy storage, buy low, sell high. That's load leveling. You're looking at daily cycles. Ramping benefits, if you look at this ramp right here on the incline and on the decline of the load shape, you'll find that, in fact, the load is going up and down during the ramp. And storing energy during the ramp can smooth out that ramp.

And the ISO -- I'm sure Dariush knows about this better than I do -- needs ramping capability here in the State of California. They need regulation capability.

And short-term storage like batteries, flywheels, super caps, handle this kind of duty very very well. And, in fact, compressed air and pumped hydro, if you built it, would have this capability. But you wouldn't justify that one benefit to build a compressed air plant or even a battery. You got to add all the other benefits.

Then if you look at the detail of one of the load shapes right there, you'll find that it's quite jagged. And there's frequency response capabilities that energy storage plants have that would take a burden off the cycling coal plants, the cycling combined cycle plants.

And right in here is where wind energy and many other variable frequency fluctuations occur. Energy storage plants can operate in this domain, as well. And in fact, Beacon Flywheel is offering a system to do just that.

So you have different applications and different types of technologies appropriate to each application.

Now, with wind, or even I could convert this word wind to renewable, if you combined these renewable resources with their fluctuating outputs, either they'd be due to sun or due to wind or whatever, with storage you can develop a relatively simple control system and smooth out those fluctuations quite economically.

So if you really want to look at all the storage technologies besides pumped hydro, compressed air, flywheels, batteries, super capacitors -- for those that talk to me later I'll tell you what the difference is between a super cap and a regular cap -- you have SMES, superconducting magnetic energy storage, thermal storage that was talked about earlier, reversible fuel cells produce hydrogen. You can store hydrogen. That's a storage technology, generally not very economic.

And you can just store hydrogen, as is, through electrolyzers and use hydrogen back through a fuel cell and have storage. So there's lots of different alternatives.

This chart, I call it the bubble chart. On the vertical axis is the power capacity of a given application requirement. The horizontal axis is the amount of discharge time you need.

So if you want frequency regulation, for example, you might need .1 megawatts to 10 megawatts or 20 megawatts. But it's in the time zone of 15 seconds to 15 minutes.

If you needed load leveling you really want something up to and including 1000 megawatts. And it goes from one hour to let's say ten hours.

So you could look for the different applications, spinning reserve, VAR control, whatever, and you can get a rough idea through this chart what type of time domain you need for the discharge, and what type of megawatt domain you need for the output power.

If somebody would get me a glass of water it would be helpful.

And what I wanted to highlight here is that when you look at storage technologies there's two dimensions. Whereas if you look at a generation technology, it's really a one dimension. You buy so many megawatts of gas turbines -- thank you, Gerry, that's very kind.

As a consequence, when you go generation planning with the generation technologies, you just look at the price -- the amount of megawatts you want to buy, and then you look at the heat rate or cost of fuel used during the generation cycle, and you do the economics.

In storage you really got another dimension. You pay for the power, but you also have to pay for how many minutes or hours of storage you want.

So if you wanted a one-hour battery, you're going to get a cost for a battery in dollars per kW. Very different than if you had a three- or five-hour battery. Because you got to buy more cells. So you got to look at two dimensions in this picture with storage.

And this chart is a little busy, but it's quite insightful. And what I show in the far right column is the range of capital costs to buy and install various storage technologies with different hours of storage. This H here stands for hours of discharge.

So, let's take a simple example that most people think they know about. Let's look at a lead acid battery. A lead acid battery, I'm say, costs today in 08 dollars of somewhere between $1500 a kW to $1900 a kW. And that's for a three-hour battery.

So that means this 10 megawatt, let's say three-hour battery, this 10 megawatt battery could produce ten megawatts flat out for three hours from full charge to full discharge. That's what three hours means.

But how do you get this cost? How do you get the 1500. The 1500 is arrived at relatively simply. The cost of the invertor is this column here, the power component. So about $300 to $400 a kW just to buy the invertor that does ac-to-dc, dc back to ac.

Every hour of storage, the number of cells in the battery, costs about $400 to $500 a kW for each hour of storage. So if you want three hours, three times $400, on the low side, is $1200. Plus $300 for the invertor. $1200 plus 300 is 1500. So this number 1500 is three times 400 plus 300. On the high side is three times 500 plus 400, and you get 1900.

The important thing is notice that if I change this hour of storage from three to four, I want one more hour of discharge, I've got to add a minimum of another $400 a kW. Every hour of storage costs about $400 a kW. That's very very expensive.

Whereas if you go up to compressed air storage, as an example, every hour of storage only costs about $1 a kW. Huge difference. That's why you can afford ten hours of storage for a compressed air plant, whereas if I put ten hours of storage for a battery I have ten times 400 and I get to 4000, plus 300 for the invertor, I get to 4300. So you're never going to see a ten-hour lead acid battery. It's just too damned expensive.

But you will see 10 and 20, 30 hour storage for compressed air. So this column right here gives you the per-unit cost for additional hours of storage for any one of these types of storage technologies.

These technologies, the low numbers here, are your baseload storage technologies. These technologies that have sort of medium-sized numbers are your intermediate storage technologies. And the ones that have very high cost, here's a super capacitor, $12,000 a kilowatt for every hour of storage. You only going to afford one minute of storage. You can't afford an hour of storage. These are way too expensive. But for frequency regulation all you need is one minute, that would be a good application.

So this capital cost table is very insightful and it shows you quickly why certain storage technologies are good for long hours of storage, medium hours of storage or short hours of storage.

This one slide, by the way, is not too often presented. So you're very fortunate that I'm presenting it to you, because it's got a lot of good information in it.

Now, the next slides, just pictures and examples of pumped hydro. This happens to be a picture of the Alabama compressed air plant. Here's a picture of the German 290 megawatt Huntorf compressed air plant. That plant went into operation in 1978. This plant in Alabama went into operation in '91.

This is a picture of the schematic mechanical engineering diagram of the Alabama plant. I won't bore you with the details, but you have compressors, you have expansion turbines, you have an underground storage system -- it happens to be a salt cavern -- and a generator. And there's clutches and you run it one way for compression, one way for generation.

There's a new design that's out. We call it the advanced compressed air plant schematic. Notice it looks simpler. That's, in fact, true in my professional opinion. And it's built around a combustion turbine.

This plant, the new compressed air design that EPRI's going to build some demonstration units, actually has a combustion turbine as a central core of the plant. So you always have a CT there regardless.

And it uses compressors for compression at night; has some expanders. There's no high-pressure combustor. There's only the combustor that's in this CT. Whereas the previous design has a high-pressure combustor and a low-pressure combustor. This high-pressure combustor produces a lot of NOx. The newer design doesn't have a high-pressure combustor, so it's got very low NOx. So whatever the CT produces, that's it's NOx.

The heat rate for these plants is extraordinarily attractive. During generation the heat rate is 3810. The charging energy ratio, how many kilowatt hours of electricity are needed for each kilowatt hour of output, .7. Very attractive. And we're very interested in working with utilities to build these plants.

EPRI's got a project out; we've got nine letters of intent from different utilities to participate with us to build, like I said, a 300 megawatt, below-ground plant with ten hours of storage, a 15 megawatt, two-hour aboveground plant. So if you're interested, talk to me more about that later.

This is what the machinery looks like. There's the motor generator in Alabama. These are the compressors. The expansion turbine's back there.

These are the geology opportunities in the United States. I just did a study for Pramod and Mike Gravely a year or so ago. We found a couple hundred sites in California that have not been used, that could be used for compressed air. There's lots of sites in other parts of the country.

The Alabama plant happens to be about where this dot is right here. You can see the dot.

A battery plant, this is the Chino battery built in '88 or so. This is a 10 megawatt, four-hour battery. And these are lead acid batteries. And we cycle them and they work just fine. It's very interesting.

One subtlety. This is really unheard of for most power plants. Batteries and super capacitors have a very unique feature that when you operate them in part-load, let's say half of their rated power, they're more efficient than they are at full load. That's startling.

Usually if you took a gas turbine at half load it would be a parasite. It wouldn't even generate anything. A coal plant at part load, the heat rate jumps up very high. Very poor.

Batteries have an opposite characteristic in terms of efficiency, part load. So they're very very attractive for regulation duty if they live long enough. A lead acid technology, unfortunately, has great part-load characteristics, like any other battery would, but it has to be replaced about every eight to ten years because they just don't have very good chemical lifetime.

But why do they operate a better part load, because I-square-R losses are less. the voltage of a battery stays relatively constant during discharge. It changes a little, but most of what happens at part load is the current drops by factors of 2, let's say, at half load.

When the current drops by a factor of 2, I-square drops by a factor of 4. I-square-R, a factor of 4. So the I-square-R losses go down as a factor of 4 at half power. So it's actually much more efficient at part load. And it'll always be true in that case.

Flywheels. Inside each of these cylinders is a flywheel. And this is from Beacon. They've got 100 kilowatt, 15-minute flywheel out there. It looks pretty attractive.

This is what a SMES device looks like. This is a 10 megawatt, three-hour -- three-second, I'm sorry, 10 megawatt, three-second SMES coil. It was built, oh, gosh, about 20, 30 years ago up in Tacoma, Washington, on Bonneville's system. And it was used to regulate the cycling resonant frequency between the northwest and the southeast -- the southwest. And it worked pretty good. Unfortunately, it was an R&D project from the DOE. And when it was all over they dismantled the magnet.

And this is what we call a 3 megajoule

coil, super magnetic coil. And it was operating at 11 degrees Kelvin. Liquid helium. Today, if we did this again, we'd use so-called warmer superconductors and operate it around 77 Kelvin. Still pretty -- that's warm, but still damn cold. But they can work; it can be built. But it's very expensive.

Super caps. This is a picture of the HECO, Hawaiian electric super capacitor. In this trailer there's a capacitor and invertor.

If you do the value proposition you better look at not only low leveling benefits, these dynamic benefits. You should look at strategic enhancing renewable benefits. A CO2 reduction; mitigate the uncertainty. Storage acts as a shock absorber. It can smooth things out. There's value there.

You should look at your corporate goals, your customer perspective. And you got to look at all kinds of value proposition issues when you look at storage, not just one.

This is what a dispatch curve would look. In this case, this is a compressed air storage plant, actually. This plant is running in the blue, so it's discharging in the blue and charging down here.

These are some studies I've done for some different utilities throughout the country. You could look at the benefits in millions of dollars per year as a function of high-wind penetration to low-wind penetration. What's the price of your offpeak energy from wind, low, mean, high. You can actually do these chronologically based value propositions. This is done with EPRI's non historic software.

This is typical for the Alabama plant, actually. People think you charge and discharge a plant every day. This is Monday, Tuesday, Wednesday through Saturday and Sunday.

And what you find out, if you do your homework properly, you'll find that your offpeak energy is cheapest on Friday night and Saturday night, rather than every night of the weekday, Monday, Tuesday through Thursday.

So this code, properly in Alabama, figures out that it should be doing most of its charging on weekends, the nights of the weekends. So it compresses, discharges, compresses, discharges, but by the time you get to Friday afternoon the cavern is at its lowest pressure.

Then it does all its recharge on the weekend. And that's why the Alabama cavern is 26 hours. It goes from here to there in 26 hours. So you got to do your homework.

This is a news article from the Texas grid that I mentioned earlier, February 26th, the day before this news article was written. There was this ERCOT emergency where they had to curtail their industrial loads because their wind generation went down and they didn't have good forecast for their wind, and they over-estimated what their spinning reserve was going to be able to do. So they had to cut out, I don't know, something like 500 megawatts of their industrial load.

We don't want this to happen to renewables. So storage could solve that.

And I'm going to end the presentation with these four guys, and talk about 20, 30 years, it was mentioned by Raymond a little earlier. Here's our different Edison, dc, dc, dc. And here's that little light bulb. And in 1879, December 31, 1879, in fact, is the day he showed his successful light bulb to the general public in a little town called Menlo Park, New Jersey, just on the other side of the Hudson River.

And between 1879 and about 1920, let's say 30, 40 years, 40 years, the light bulb revolutionized the world. Everybody that had gas lights virtually in the world converted to electricity in 40 years. Without computers, without the smart grid and without all these fancy tools we have today.

But in 40 years this guy, amongst these other guys I'll talk about in a second, they did a phenomenal revolution. They converted from fossil lighting to electricity lighting. And Tom Edison is to be given a lot of credit.

Now, he happened to choose dc rather than ac, but he did invent the light bulb, among other things. And I would think that if he saw the skyline of any city in the United States at night, he had a dream about his light bulb. But I think that what really occurred has far exceeded his dreams. It was pretty impressive what really happened with that little invention.

And by the way, he's standing in front of his invention of the electric street car. He actually had a manufacturing facility producing electric street cars, and that's why I got this picture. So he did quite a lot. And these were dc motors, by the way.

This is Tesla. This guy is really the brainchild of our electric grid today. He was the one that educated Westinghouse, the mechanical engineer Westinghouse, to come up with ac systems. He invented the ac induction motor. He invented the fluorescent light bulb. He invented the radio, by the way, it wasn't Marconi as some people think.

He invented three-phase ac power flow; poly-phase ac systems. He figured out what VARS were, and even today a lot of people still don't understand what VARS are. But, this guy is really to be given credit for our ac system that we have in this room today, and virtually everywhere else in the world.

We have 60 cycle in this country because of him. He specified 60. Edison specified 100 volts dc. And why do we have 110 volts in our plugs today? Because the ac guys decided to go RMS about 110 volts.

Westinghouse was the mechanical engineer that bought Tesla's patents. They created the first ac power plants.

And this guy you probably don't know about, but his name was Steinmetz, Charles Proteus Steinmetz. He invented the use of the square root of minus 1 in all our engineering calculations. And I'm sure all of us did homework with the square root of minus 1 many many years ago.

But it was because of his mathematical prowess that he figured out he could use imaginary numbers to calculate magnetic forces in ac and dc machinery. And he actually is the guy that made the mathematical modeling possible to design ac machinery. And that's Steinmetz.

And he became the head of the so-called computation department at General Electric in the early days, about 1930, 1940. And he didn't even have computers in those days, but they called it the computation department of General Electric.

So, I always pull these guys out. But what can be done in 40 years is astounding. And it's a shame, it was mentioned earlier, that 30, 40 years ago we did all this work in renewables and we're still standing here trying to do more work in renewables.

These guys changed the world in 40 years. So we really need to take ourselves a little more humbly and ask ourself why are we so damned slow. Compared to these guys we are really slow. So we got some work to do and some catch-up.

So that's my presentation. Any questions now?

MR. WHITE: Can I just ask if from here, would that be okay?

DR. SCHAINKER: Sure.

MR. SPEAKER: No. You have to come to a mike or it's not on the record.

MR. WHITE: I'm Keith White on the PUC Staff. Could you comment on whether you think that storage can be adequately analyzed and compensated based on the standard market products we have now, the time and location differentiated energy prices and the various ancillary services prices?

Because I'm familiar with some studies that have tried to do that, and they've always had a hard time justifying storage, and something seemed to be missing.

So, I'm interested in your view on that.

DR. SCHAINKER: Well, I happen to agree with you. Our current price structure is wrong.

It's not right.

There is value to the customer base that is not being remunerated to the people that are providing those services.

For instance, VAR support is not being paid enough, if at all. Regulation duty has got a little payment, but not enough. Our current pricing structure is just dead wrong. We've got to change it. And it's going to be very tough, because the lawyers got to be convinced, and it's very very tough.

So, as engineers in the engineering economics we've got to work with the lawyers that are setting all these bills in motion and get that changed. Because we really have a big problem, it's a huge stumbling block, in my opinion.

So, I agree with you.

Yeah, Raymond.

MR. DRACKER: Just a followup. Yeah, the storage I presented earlier has got to make it purely on buy-low/sell-high. So, it's not easy.

But along the lines of, you know, went through this issue of how you make a storage plant economically justifiable when in the current or the market certainly in the 90s, you know, you sort of, you don't have the ability to integrate the benefits under a single utility's tent and make it go.

But the LEAPS project has been on the drawing board. Is that going to go forward? Does anyone know about -- that's the pump hydro project in southern California, right?

DR. SCHAINKER: Huge pump hydro project. It's been on the books for years.

MR. DRACKER: I thought they figured out how to get together, Cal-ISO, DWP and say, okay, these are all the benefits, let's run with this project. And so --

DR. SCHAINKER: I don't know the answer. I've not heard it. If the LEAPS project is going forward, it would have been a front-page article. I've not seen it. So, I -- there's something wrong there, I don't know what it is.

The guy that might know is Dave Hawkins at the ISO. He's --

MR. DRACKER: Okay.

DR. SCHAINKER: -- been involved in that LEAPS project. I don't know where he is right now.

MR. SPEAKER: He had to leave; he

had another meeting.

DR. SCHAINKER: Oh, he had another meeting. But you know Dave Hawkins, don't you?

MR. DRACKER: Yeah.

DR. SCHAINKER: Talk to him; he'll know the answer to your question. I don't.

MR. DRACKER: But actually my real question is, or my question is do any, besides, you know, you talked about the various technologies, how they fit in energy versus power in the mix. Are any of the non sort of mechanical, except for SMES pumped hydro and macro SMES, if it ever makes a comeback, any of the other technologies, flywheels, advanced batteries, make it in this four- or five-hour storage, in your opinion?

DR. SCHAINKER: No, well, first, in my opinion, flywheels won't make it, for sure, five hours. It's only, at most, maybe five minutes.

MR. DRACKER: Okay.

DR. SCHAINKER: It's way just too expensive on a dollar per kW basis, for each hour of storage, just won't make it. Super caps definitely won't make it. SMES won't make it.

It goes back to this chart that I was

showing you earlier.

MR. DRACKER: Right.

DR. SCHAINKER: If the --

MR. DRACKER: I wasn't sure, you know, if, you know, any of the batteries might --

DR. SCHAINKER: Okay, now the only battery that might, this is a good observation here. Well, I'll use this pointer here. There's an advanced battery called sodium sulfur, and you may have heard about it.

Now, it's as very dangerous battery. Just, I'll put that to rest. I mean it's got molten sodium and operates 650 degrees Fahrenheit, it's a dangerous battery.

It's got to work and work safely. So, the Japanese bought all the licenses from the Germans and British and all. And they built some pretty good batteries. None of them have caught on fire that they told us about. And they seemed to be working. So they've done some really good work.

But they're expensive. They're at least $500 to$ 800, maybe even $1000 a kW per hour storage.

Now, sodium sulfur, when I looked at it

years ago, should have been able to come down to $100 a kW for each hour of storage. That was the dream. This was back in 88, let's say.

That's because if you do your analysis on just the cost of the materials and you multiply by about a factor of four, you get about $100 a kW for each hour of storage.

But they're selling these batteries, because they don't have a manufacturer facility it's all in preliminary engineering and all those costs are in there -- they're selling them up to $1000 a kW for each hour of storage.

So, ten hours, so your sulfur battery's going to cost you, right off the bat, you know, $10,000 a kW. I mean it's just too expensive.

They are taking some losses on the first batteries they are building for (inaudible) Power and Nipe (phonetic) and a few others. The Japanese are taking losses on them.

But in the long term I do not see that battery being even 7 hours --

MR. DRACKER: Because in terms of, you know, fitting the bulk renewables into a desirable production profile from a California grid standpoint, I think you need three, four, five hours minimum. And so I've heard it asserted that perhaps, you know, there's a battery or some other kind of technology that might do that --

DR. SCHAINKER: Well, --

DR. SCHAINKER: -- but I had my doubts. But I just didn't know --

DR. SCHAINKER: A three, a three- to five-hour battery I could believe. Lithium ion might make it. A zinc bromine might make it. And it's possible.

But there's still some technology improvements that have to be made in those so-called flow batteries. So that's the answer to your question. Okay, sounds like we're good.

Anything else? That's it. Thank you. You can change it to another person.

MR. BRAUN: Okay. Our next speaker is Merwin Brown from California Institute for Energy and Environment.

MR. BROWN: Thank you for the introduction and getting the slides set up for me.

I'm going to be focusing on something that's different today so far, which is technologies that can change the transmission system, other than perhaps storage, I guess, would fall in this category, that would help us better deploy renewable technologies into the California system; and even import it from outside of California, if that's what we decide to do.

So, I'm going to be talking about a rather complex system, the transmission system. An if you hear a lot of moans and groans among the audience, it's the electrical engineers who are distraught and upset by my over-simplification of what I'm going to describe for the transmission system in order, one, to have time to get this done in time; and secondly so that I and others who aren't electrical engineers, can understand it.

So, bear with me, please, those of you who are among the more educated in this area.

What I'd like to do is first of all talk about what I call the saga of renewable and transmission integration. In other words, how do we bring these two things together and have them work and live in harmony.

So, I'd like to start my saga with discussing this somewhat from the viewpoint of a renewable power plant owner. I'm going to use wind in this case, but you can use other renewable plants. And there will be a slight change in the story as you go along. But a lot of these things will occur on most renewable power plants.

Now, being a smart owner of a renewable power plant, this person is, like Oak Creek Energy, is going to put their power plant out where they get the most wind. Because then they produce the most energy and they produce, therefore, the cheapest kilowatt hour or they sell enough kilowatt hours, I should say, to get more revenue in for their plant and technically make more money.

So, that's where they go. They go where the wind is. So the first question they're going to ask, though, is how do I get my electric power to market. So they say, aha, -- whoops, what's happened here? Oh, I'm sorry, the slides don't work out real well.

Okay, that is supposed to be a transmission system -- I don't know what happened in the process -- that takes the power to the cities and other areas of population that will use it.

And you may notice that one of the first things is there's a big gap between where the power plant is and where the transmission system is.

So the first thing that needs to happen is the transmission system needs to be able to provide access to that power plant. About the only way they can do that is they need to build additional transmission lines.

Now, one of the problems is in today's world it's very difficult to get a transmission line built. And it takes awhile. And that's why it was kind of stuttering there. It's a stop-and-go process today. And it can take a long time.

But eventually hopefully we get these transmission lines extended out to the power plant so they can now get their electricity to market. And so now the power plant owner can breathe a sigh of relief. But it turns out that the owner's premature because of the transmission operator points out something to them that their power plants have some unusual behaviors for which the grid wasn't designed to operate.

And also the operators aren't familiar with this kind of operation. And one example of that is intermittency. But there are other characteristics of some renewable plants that also bring some unusual features into the power grid system.

So a second thing that the transmission system needs to be able to do is to accommodate renewables' unique behaviors. Now, we're ready to go to market says the power plant owner.

And so he starts to do that, and right away runs into another problem. It turns out all this transmission, existing transmission, out there is pretty much overloaded, particularly during peak times. And so it runs right into thermal limits. In other words, you can only run so much current through these wires before they get too hot and they either sag into something like a tree and cause an outage; or they get hot and damage the lines, and then there has to be repairs made.

So, right away, the power plant owner says, transmission, you got to find a way to get more of my power to market. I'm limited. So the transmission owner needs to work on that.

But even if you get that problem solved, another types of problems showed up, called instability, deratings. Now, these are a whole host of various kinds of unusual behaviors on the grid, or unacceptable behaviors of the grid, that show up at different places and different times.

But what happens is if the utility operator and the owner doesn't take these into account and derate the amount of power they're sending over the system, they run the risk of having outages.

And this particular one that I'm showing here was an oscillation that occurred in 1996 on August 10th, that ended up blacking out most of the western United States. So these are serious things.

And this particular one, if these instabilities were sharks, this would be the great white shark of instabilities. It's the low frequency grid oscillation. It can have very wide area impacts.

So, right away there's another limit that the power plant owner faces in trying to get their power to market. And so that means that somehow the power grid's got to increase capacity.

So, bottomline is in order to fulfill its renewable integration mission, the transmission system has got to achieve at least these broad objectives.

One of them is to provide physical access for each new power plant. The other one is to be reliably accommodate any unique renewable generation behaviors. And then the third one is increase its power-carrying capacity to handle the additional electric power flows that these new power plants will bring.

Now, in order to meet these three objectives, and say a 33 percent penetration level of renewables, there are a number of things that I think need to be considered.

First of all, there is the traditional build solution. And that is that transmission owners invest in wires, towers and power plants. And that's the way it's being done now mostly in meeting these demands.

But, as we increase the penetration of renewables, this approach becomes lee and less likely to be able to handle it alone. As a matter of fact, some stakeholders have told us that we're already at that point where the build solution, alone, won't do it.

But there are new transmission technologies, that could be deployed if they were developed, that, at a minimum, can make renewable integration easier and perhaps less costly than the traditional buildout solution if that were your only solution.

And probably the best way to look at that is these new technologies endow the transmission system with improved and new capabilities.

So, in order to accomplish these three objectives the transmission system has got to obtain improved and new capabilities. And here are examples of some of them.

In providing access, and by the way, I'm talking about the transmission system in forms of a community, it's not just the infrastructure, but it's all of the institutions that surround that infrastructure.

And so one of the things it needs to be able to do is provide faster siting than we have right now. It just takes too long in order to get transmission in place and also to get it approved in order to meet the demands that we want to achieve with the deployment of renewable generation.

And then for accommodating the interesting behaviors of renewable generation there are a number of other capabilities like, one, to be able to help and give the renewable generators sort of an equal footing in participation in the power markets, which right now it has a difficult time doing.

And there is being able to accommodate its dynamic behavior. This is how it behaves during disturbances on the grid, that is the power plant behaves.

And then there's operating coordination. In other words how do the renewable plants coordinate with other power plants, particularly in startup phases or ramping phases.

And then there's the ramping aspects of renewables, itself, which tend to be, for the most part, faster on the uptake and on the slowdown than traditional power plants.

And then there's handling excess total power and minimum load, a reasonably complex subject. But if we meet our goals with renewable energy we are going to run into cases where there's extra generation above and beyond what we need. And we'll have to back off some existing power plants which can create a problem with some of these stability problems I was talking about.

And then there's the increased capacity. One, we'd like to find technologies to decrease the thermal constraints. And then we would like to be able to also decrease the stability constraints. And there's three major kinds, voltage, transient and dynamic.

And then we need to plan for the transmission system expansion, which is often the subject that's forgotten about until one goes to thinking about how to do these things.

So, in order to get -- some new technologies we can talk about to provide faster access for new renewable plants, could be deployed by putting new transmission lines in a better light.

And this is meant to be kind of a pun, because there's two ways that I mean this. One of them is that you actually hide the transmission system, take it out of the light, or at least you use new technologies that allow you to make it less objectionable to people who don't like to see these things.

And the other aspect of it is can we change the way people look at transmission, the way they look at the value and things like that.

So there's a list here of some technologies. The first half of them are technologies that would change the way the physical aspects of the lines, from undergrounding to using advanced transmission conductors that would reduce the footprint of these systems.

And then the last half of these technologies are processes that would hopefully increase the knowledge of everyone involved in the decisionmaking process of whether or not to accept a transmission system.

And also bring in some things, for example, that in the past have kind of been ignored. And I know that Robert brought them up, in the storage area, which is strategic value, which often don't make it into the decisionmaking process, and should.

And so going on to look at some new technologies to help us accommodate unique renewable generation behaviors, here we would use them by making the grid smarter and more flexible in order to handle such things as intermittency.

And here's a list, again, of technologies that could make a difference. And you might notice that energy storage is right at the top of those. It could go a long ways of improving the ability to integrate these new types of generation.

And we had earlier this morning the talk of forecasting tools, which can also go a long ways. And then there's a list of other things, such as synchrophaser measurements that Mike mentioned in his presentation.

There are such things as power flow control, and here I'm talking about the special form of power flow control, to determine where power flows. But there's also another form of power flow control which is the storage form, which is a temporal form of power flow control that also fits into that category of power flow.

And then there's a number of other things, demand response, distributed generation, generator and load modeling is an important factor in all this that may not be obvious to all of you. Statistical and probablistic forecasting tools that were talked about earlier today. And advanced intelligent protection systems.

And then last, some technologies that would allow us to increase the capacity by fine-tuning the grid for greater power flow. And, by the way, in this picture of California these colored ovals are areas of constrained transmission where we would have difficulty in putting much more increased power flow into these areas.

There are a number, about ten of those within California. And there are two major bottlenecks of bringing power into California from outside. And these are constrained by a number of different things, such as thermal constraints, stability constraints and other things related to reliability.

In some cases, for example, up in the north there, on the north/south COI, which stands for the California/Oregon Intertie, that particular thing has been derated from a total thermal capacity, based on its thermal limits of about 7000 megawatts down to 4800 megawatts.

And if we could get a handle on controlling some of these problems, and if you will, fine-tune the grid, we could perhaps recapture some of that capacity with relatively low cost compared to building new transmission lines.

So, here are a number of things we can

look at. There's dynamic thermal ratings that allow the operator to actually know the temperature of the line, and therefore operate with a less conservative safety margin.

Real-time systems operation using synchrophasers and applications of them which can do the same thing, by the way, for some of these instability problems.

The power flow control that I mentioned. The energy storage, again, which was power flow control in terms of time.

Advanced transmission line conductors that can carry more power over essentially the same footprint; similar with high voltage dc current.

And distributed generation is another one that would cut down on the need for transmission.

And, again, there's the things like statistical probablistic analysis and planning tools and advanced intelligent protections systems, to name a few.

One I'd like to talk about in specific, only because I see it as the heart of what I call the smart grid transmission. That is the synchrophaser measurement.

And you saw this slide a little earlier. Mike went through it rather quickly. I'm going to go through it quickly, too, but not quite so quickly. I'm going to try and explain some of this.

Synchrophaser measurements is a relatively new measuring device by our standards, where it takes 30 years to get a new technology in place. These were invented probably about 20 to 30 years ago. Happened to be, I believe, Virginia Tech.

And they were early deployed in the west mostly by Bonneville Power and WAPA. And then later on Southern California and PG&E joined in, after the 1996 outage. And realized if they'd had this technology they might have seen this oscillation problem coming, and prevented, or at least avoided, the damages from that outage.

But what this device does is it does rather rapidly collect a whole lot of information. And if placed at a lot of different places in the grid, can give you rapid, essentially real-time information about the situation at that grid.

But that's not quite so important as

perhaps this aspect of it, which is using GPS satellite to time-stamp that data, so that now by the time, say, data that was generated or collected up in Canada is collected by, say, San Diego Gas and Electric, a long ways away, because of the time delay they can use this time-stamp to compare the data to know which data compares in southern California with the data up in Canada.

And that may not sound too important to most of you, but to a power engineer and a grid operator it's extremely valuable information to know. And what they get is a lot of synchronous data that shows them things like they hadn't ever seen before.

And I use the Sharp metaphor, again. Imagine that in the old days you went swimming at your favorite beach and you didn't have the latest goggles. And you were just swimming along happy and every once in awhile one of your co-swimmers would disappear. And you didn't know why. Undertow, maybe? You didn't know because they just disappeared.

Then one day you bought new goggles and you were able to see for the first time underwater. And guess what? You'd been swimming with sharks all this time. And it was the sharks picking off your companion swimmers. And you were also vulnerable at that time.

So now you can better watch out for them. That's sort of what this technology is going to do for the power grid, is allow the operators to see things they've never been able to see before on the grid, and see them essentially in real time.

Well, all this data has got to be converted into something useful, as you might imagine 30 to 60 times a second with a whole lot of data is going to overwhelm any operator. So we need to develop applications to allow the operator to be able to get some useful information out of this. And then make some decisions to do something about some kind of threat that might be coming.

So, the concluding statement built around this particular technology is, I think, ultimately we're going to find that the smart grid is going to be required to maximize the amount of renewables. I don't see any way around it without bringing in these capabilities eventually at some time. And depending on who you talk to, that's either got to be sooner or at least sometime later.

Thank you.

MR. DRACKER: A question, Merwin. So, is the idea if you have this sort of instantaneous view of -- would it allow the transmission to be operated at closer to the ragged edge of thermal instability limits, because now with this information if something does go -- something goes wrong, they can respond?

MR. BROWN: That's part of it.

MR. DRACKER: And they don't need the margins everywhere?

MR. BROWN: That is part of it, yes. It's to be able to operate towards closer to the ragged edge. And this isn't so much a desire, as it's become a necessity --

MR. DRACKER: Yeah.

MR. BROWN: -- as we balance an increasing load growth, increasing power flow, and more and more difficulty to build more transmission in order to handle it.

So we're being forced into it. And this technology, by the way, is being used today already at Cal-ISO and at Southern California

Edison. They're operators are already using this technology. And the R&D isn't even dry yet.

MR. DRACKER: But they're still operating COI at 4800?

MR. BROWN: So far, yes.

MR. DRACKER: Why?

MR. BROWN: Because that's going to take --

MR. DRACKER: That's -- want stuff to hit the bottomline faster.

MR. BROWN: That's because this is going to require a wider area of coordination. And as a matter of fact, there are meetings that we've been involved in that's in the R&D stage with entities like Bonneville and Pacific Northwest National Lab, and others that begin to look at this question.

But it's a bigger problem to tackle. Right now about all we can do is analyze the damping ratios of these low-frequency grid oscillations. Our next round of research is going to try to speed up the detection of them, so we see the sharks sooner than we can right now using the phaser measurements.

And then the second thing we've got to

do is use these things to analyze the low-frequency grid oscillations in order to mitigate them. And, again, storage may turn out to be the answer. There are other possibilities, generation, et cetera.

MR. DRACKER: I have another really low-tech question. Again, sitting here as sort of an independent power company, hoping that, you know, realizing that transmission corridors take three times as long to permit as power plants or something; and how soon is the transmission going to become available.

But, it's my observation that the biggest, the longest lead time in the transmission is permitting the corridor. And I just wonder why all new corridors are not permitted as double-circuit 500.

You could build a double-circuit 500 tower. I've never seen one in California, but it's physically possible. You could also build 750.

But, you know, whatever, if phase two Tehachapi is double-circuit 230, why not permit the corridor and build the towers to accommodate double-circuit 500. Just operate it at singlecircuit 230 for awhile.

But, I mean to me, banking that corridor is so valuable. Has that been considered at all? This is obviously not a technology question. I think it's a commonsense--

MR. SHIRMOHAMMADI: By the way, there are some double-circuit 500 kV lines in California, so.

MR. DRACKER: Double-circuit on the same tower?

MR. SHIRMOHAMMADI: Oh, yes.

MR. DRACKER: Oh, okay, good.

MR. BROWN: But in general what you're talking about is such things as using higher voltage, and using perhaps special kinds of engineering designs to allow more compact spacing. Those kinds of things.

And the answer is, I suspect, a combination of economics. It hasn't really been tried very often. And it's just difficult enough to get an average joe kind of transmission system approved, as it is. That would be my guess.

But, indeed, in R&D we've got our sights set on some of those, because eventually the transmission owners in this state and the operators are going to be backed into a corner where they really don't have any options, I think. Because you're going to run out of the ability to sight right-of-ways in any great numbers.

So I think we'll have to go that route eventually.

MR. DRACKER: But I mean it's, we're losing time because right now finally we're getting on with getting new corridors and a permitting pipeline. And, again, permit --

MR. BROWN: Right, well, --

MR. DRACKER: -- them as double-circuit 500.

MR. BROWN: -- we aren't getting that many new corridors. They aren't coming that fast. And certainly a retrofit would almost probably be the same as a new corridor when it comes to permitting. So you also have to be careful how you do that.

That's one reason maybe high-temperature/low-site conductors are interested, because you can use essentially the same weight of cable, put it on the same towers, and in theory -- in practice it's more difficult -- in theory you could double the amount of current flowing through those systems. In practice it's not that simple. Nothing's ever simple in this business.

MR. GRAVELY: Thank you.

MR. BROWN: Yeah, thank you.

MR. GRAVELY: There'll be some time at the end to have questions for all the speakers, again. So I'd like to go ahead and offer our friends from Oak Creek Energy a chance to come up a little bit now. See if I can get the right presentation here.

(Pause.)

MR. SHIRMOHAMMADI: I don't have one.

MR. GRAVELY: Oh, you don't have one, okay.

MR. SHIRMOHAMMADI: I'm going to talk --

(Pause.)

MR. SHIRMOHAMMADI: Thank you for inviting me; actually you invited somebody else, and I'm here for him.

Talking about a shark, a few years ago I was doing business in Brazil and I was in the City of Recife. And the first day I arrived was Sunday and I went to the beach. And I noticed they have the most beautiful sea in the world -- ocean in the world, Atlantic Ocean.

And everybody was swimming just about a couple of, maybe 10 feet at most, away from the shore. I said why are these people like this. So I went forward, and I was the only one who was doing that.

And I didn't stay out more than half an hour. I came out and I noticed people were staring at me as I came out. I can't imagine what the story is.

Then when I was in my meeting and I was talking about what I did. They said, well, we get one idiot tourist eaten by the sharks every week here, so you're lucky you're not one of those.

(Laughter.)

MR. SHIRMOHAMMADI: Anyway, I knew about being here just two days ago, and so -- and I'm here for the President of Oak Creek Energy, who asked me to fill in for him. He has some other matters to take care of.

My presentation is not going to be purely from the point of view of a wind developer. I'm still, first and foremost, a transmission operator planner. So I'll have -- you have to take whatever I say with a grain of salt in that sense.

A lot of the concerns and issues that are being talked about for integrating renewable resources is, to put it mildly, overblown. And for probably good reasons.

We have, for years, been exposed to wind power plants which were the most rudimentary versions. They were not probably closely attended to by the operators for a variety of reasons. Probably the income would come regardless of what happened.

They were type one generators with very little capability, no pitch control. They were all concentrated more or less in one area, so they were exposed to the same wind regime.

And worst of all, they were not owned by the utility. I worked for many years at Pacific Gas and Electric Company before, of course, going and working a bunch of other places, including California ISO.

So, they were not behaving well. And most of the operators experience with renewable resources was formed on the basis of those type of experiences. And you see that wherever you go.

And now that the concentration or penetration of wind resources is increasing, or for that matter, all kinds of intermittent resources, or -- I'm a member of a NERC working group on integration of what we call variable generation. That's the latest.

So, as the penetration of variable generation, wind generation in the system increases, the operators who have that kind of experience are dealing with integrating such resources with very little guidelines.

Just some time ago there was an operator who asked a wind power plant to go to zero, to ramp to zero. And this generator was, a wind plant, was producing several hundred megawatt. And, of course, the wind plant went to zero in almost less than a minute.

And, of course, the operator all of a sudden is short on generation because he was expecting, like any other thermal generator, this wind plant to go down over an hour or so. And then, of course, he blames the wind generator, as opposed to -- he could have easily asked, go down to zero in a matter of one hour, as opposed to go down to zero.

So, the fact that the operator, the wind plant operator followed his instruction literally is working against him.

Well, the event in Texas, in ERCOT, could have been readily avoided if proper forecasting tools were used.

So, by and large, we are short of proper procedures and guidelines in the hands of operators to manage our system better in presence of these large translation of variable generators. And we need to focus on that.

Now, if you consider that, and consider the fact that new generational renewable resources are so technologically advanced that they can give you any capability that you can get from a regular conventional generator, and then some -- I can say, for example, a type 4 wind generator will never contribute to (inaudible), for example. That's a very valuable thing, but no other generator can say that.

So, -- by the way, some solar units can say that if the output is -- has invertors associated with it -- so, if the capabilities of these units are properly used by the system operator, you'll find that you barely need any regulation. You don't need anything else more than what you need if you add regular generation to the system.

Except one thing, and that's upward ramping. That's one thing you cannot get out of a wind generator beyond what the wind allows you to have.

However, in the context of discussion around integrating variable generation, a lot of issues come to the fore, which really show that the extent, probably the discussion lacks the knowledge of a system, power system, or lacks the knowledge of the generation technologies available.

And I guess I'm lucky now after working with operating of the system and so on, I'm working with these generators and seeing what they can do. And by the way, in our discussions and work with NERC, they're realizing that the wind generators, at least wind generators, and I'm sure other renewable resources, are willing to operate according to the instructions. They have capabilities to follow the instructions.

Now, if you want to use a renewable resource for ramping capability, by my guest. The issue is, of course, the economics would prevent you to do that because it just doesn't make sense.

But if you have to do it because you have reliabilities, we can ramp it down. I mean there's nothing there that can prevent you to do that.

The way we're working with NERC these more and more conditions will come out that will make renewable resources part of the power system community, as opposed to outsiders that the utilities and operators are looking at -- that frown upon them.

So, in order to integrate large amount of renewable resources as you're seeing happening in Europe and so on, there are a bunch of things you can do. And I'm going to quickly go through some of the things that comes to my mind. And, by the way, I prepared my presentation while sitting there. If I was -- you saw me writing frantically. I was not taking notes on your presentations, I was putting together some thoughts to present to you.

The first and foremost is what I just already said. The operators, to use the capabilities of these generators to the maximum, and work with them, and if you have to dispatch them, considering, you know, the -- cost of dispatching them down, ramping them down, is whatever it is.

Well, that's the decision the operator makes, and a lot of renewable developers would be willing to work to make that happen so that they could -- that we would have a much more easier acceptance of renewable generation in the system. And integration would not be blocked based on -- forgive me for saying this -- bogus reliability reasons.

The other issue is we have operating -- not only the operators do not have -- have not yet gotten used to what operating practices they should follow in operating renewable resources. For example, not saying ramp to zero, which the guy will do, and he says, oh, I've lost several hundred megawatt of generation.

But also, of using better forecasting tools, which is extremely critical for the whole thing. Is completely rethinking operating practices, planning and operating practices.

The deterministic planning practices which we have been working with, and operating practices that we have been working with for -- in our industry nothing changes, by the way, nothing changes until there's a gun to our head -- and so for decades, simply because deterministic planning is simpler, is causing two issues. Over-design in transmission, over-building transmission, which I would never say you're over-building transmission because we have so little transmission.

But worse yet, it will block interconnection of renewable resources if you purely stuck to deterministic planning and operating criteria.

A few years back when I was at Cal-ISO, in fact I went through that peak condition, the one-in-ten, or in fact, maybe one-in-20 peak condition. I was in charge of operations planning at Cal-ISO at that time, for the southern grid.

And we were going through this, and of course, we had the highest loads ever in the system. And the wind was at its lowest point, one of the lowest points that it had. And yet nothing happened.

Because if you look at it deterministically, if you look at things deterministically you would never plan for a condition like that. You should, by the way, that condition.

But at the end of the day a series of things should happen together for a system to fall apart. It doesn't always happen that you have the peak-peak load condition, you have, you know, one of the lowest wind condition, and you have a major contingency in the system.

You have to consider all these have priorities. And if you want to design your system for, you know, something that could happen once every 100 years at deterministic planning and operating criteria forces you to. Of course, you either prevent good things to happen to your system, good optimization of your system. Or you prevent good resources to interconnect to the grid.

So, I think operators need to become a lot more familiar with operating these type of resources.

The other thing is I focused on the issue of ramping. the ramping is basically the only criteria, the only requirement that we need to focus on as far as I'm concerned. Every respectable study I've seen on integration of resources they have identified that that's one area we need to focus on.

Load following, that's actually what it's called, load following. This is as opposed to frequency regulation.

And, for example, that problem that I see can be resolved with expanding a balancing authority's footprint. So you can say that -- and by the way, that's done by either resource-sharing type of arrangements, or more than that, or formation of ISOs and RTOs, which have been very helpful in helping with integration of renewable resources, because they allow more ramping, they provide more ramping capability to be available to the operator, to the balancing area operator.

But if you look at the existing operating criteria, CPS-1, CPS-2, for example, and if you think about those, those are really reliability related. They're mostly economic related, economic criteria. They're just trying to make sure that not too much power shifts between two balancing areas.

By simply modifying those you can allow a lot of renewables to be implemented. And even areas which do not have large footprints, which do not have powerful ramping capabilities.

I really am hoping that what I said is

not an indication that, okay, we have no problem. We have the need to add resources to the system, technological solutions to the system, where not only on top of dealing with operating procedures and better education and better understanding of what the issues are.

And, to me, to provide that kind of -- as I focused on the issue of ramping, and that's where you see most of the time people are talking about firming up systems, firming the renewable resources. To me it's not firming renewable resources, but making sure that the system, overall, has a firm output.

And when it comes to firm, by the way, I don't mean nuclear baseload firm. That's not firm, that's probably the worst type of unit to integrate in a system. You have to worry about it more than anything else, because it doesn't go down, it doesn't go up. And if it goes down you have to wait a couple of weeks for it to come back up.

And I don't remember we ever worried about integrating nuclear power plant in that sense, in the sense of integration.

So, coming back to these, I think we

definitely need more resources that help us integrate more variable generation, because we need variable generation for millions of reasons.

When I say variable generation I'm talking about renewable generation.

And I quickly will go through a quick list of what I think is good, and why it's good. And most of you folks actually focused on this component, what I'm going to talk about. So, I'm not going to -- I probably don't know half as much about this stuff as you do.

But I'm going to look at it from the point of view of a system operator, and a wind power plant operator/developer.

As you probably know, CTs have been -- have been used a lot for firming up wind generation. And I think that they should be -- the only good thing about them is that they're proven. They are inefficient, polluting and especially the type that has been installed in downtown areas to deal with peaking conditions, probably run a couple of days a year, or maybe five days a year, maybe a week a year. All that expenditure.

And I understand that the numbers that

have been there for peaking units that Edison implemented in downtown, in L.A.Basin are quite high, actually.

The other one which can work is diversity diverse renewable resources. Wind and solar in many times, in many ways, complement each other and provide you with all the capabilities you need. And the profile that you would need, as well. So, that's one way of doing it.

But, to me, like many of you, I think storage technology is the best solution. The concerns, of course, with that is that the technologies are still being developed. And it's such a pity because they're being developed for the past so many tens of years. It's such a pity.

I can squirm at the thought, you know, if telecom or computer companies were acting like utility companies, where we would be. Or other industries could survive without -- while using 1920 technologies, as we are in our industry.

Most of them would not survive a day without implementing the latest R&D, things that come out of the R&D facilities.

Now, when I say that storage is, to me, the best solution, it's not only because it provides what is essential, which is ramping capability and other capabilities you need. But also it provides many ancillary benefits for the grid.

And as was mentioned earlier, it's the combination of those ancillary benefits and the benefits they provide for integrating renewables are critical for eventually justifying them.

And, of course, they could be operated in such a way that the output could be always clean power.

I'd like to close my talk by saying that tying the storage technology, for example, to need for integrating resources is an incorrect notion. We need a storage technology with or without integrating resources. We have needed the storage technology forever.

Except that when you -- whatever it costs you to produce and distribute and transmit electricity, you get that an pass it on to ratepayers, and you're guaranteed revenue, you never think about those type of things. You never think about bringing efficiency to the system.

Storage technologies are needed in our system in order to make the system, as a whole, operate better. And they, of course, have the absolute benefit of allowing more renewable resources to be integrated, or be integrated more smoothly.

But we need storage, and we have needed them, and I was very glad that Merwin Brown asked that question. Why don't we have more storage technologies now. And I guess the answer still goes back to if you don't have a downside to not doing it, why risk it.

I'm done. I'm glad, by the way, I don't have a handout. If I had a handout I'd probably end up in --

(Laughter.)

MR. GRAVELY: Thank you. Chance for one quick question. Anybody have any quick questions before we go.

Okay, then we'll hold it till the end. And we now, real quick, the last few presentations, we're going to make a discernible shift a little bit and look at distributed renewables.

One of the things both myself and Gerry have begun to look at in our research programs. is the fact that there is a large amount of these resources coming onto the grid. And in some cases they count for the 33 percent, and in some cases they don't. In most cases they don't count.

There's comments about this in a handout that we got from one of our consultants that I had to do a little quick work for us. And so we want to look at that and think about that, too, as we go forward. There may be a day when, just like they do today in demand response, where you have aggregators who bid into markets with load. You may have aggregators aggregating renewables to control them, also.

With that I'll turn it over to Dan.

MR. STEELEY: Okay, thank you. My name is Bill Steeley, and I am standing in for Dan Rastler, who was originally asked to be here and he's in Ohio right now.

And what I'm going to do is talk about the Electric Power Research Institute's DG and energy storage program, and where it touches ongoing efforts to increase our renewables penetration.

So the outline I have today is basically going to talk about our roadmap and the program that we have in program 94. And basically where we've been using energy storage, which is mainly in grid support applications.

And then I'm going to end the presentation by talking about a few projects to assess opportunities for distributed PV and wind energy within our DG and ES program.

Here's a roadmap of our program at EPRI. And as you can see up here we're starting some case demos that Robert Schainker is heading up. And also some smart grid demos.

And in program 94 we kind of have like three buckets of projects. One for technology assessment, technology watch, economic analyses that we do. And then we're doing tests and validate various options. And mostly right now we're concentrating on energy storage, sodium sulfur, zinc bromine, vanadium redox battery, K (phonetic), lithium ion, hybrid DG systems.

And in here we're starting to integrate renewables, which is coming up. We've already started, and we have a couple projects on that this year.

Also, another bucket is the interconnection and integration area, looking at how we integrate distributed resources, including energy storage and spot grid networks, as well as the regular radial system.

This just gives you kind of a snapshot of the different technologies we're looking at here in our distributed generation energy storage program. And up here the bulk energy storage would be where the K goes, and is connected to the transmission system.

What's new in DG? We're focusing, like i said, mostly on energy storage, but Dan is actually heading up the project to look at a Rolls Royce hybrid, or solid oxide fuel cell hybrid system that's a 1 megawatt size.

And it looks like it could come in at about 60 percent efficient operation. And doing an economic analyses on that it looks like it could be competitive with some of the existing technologies. And it's of a size that the utilities are interested. So we've been pursing that. And the first field demonstration unit is planned at AEP in 2009. And this is kind of a picture of what this system will look like.

Here's examples of some of the fossil fuel DG that we've been working on. And that we want to be able to integrate with energy storage systems.

And right down here is a very small 1 kilowatt micro-CHP system that's getting used especially in the northeast. And their next model they're going to integrate PV with this so that I can handle photovoltaics, as well.

Distributed energy storage systems are gaining market adoption for grid support applications right now. And here's three examples of where this is happening.

And at the same time we're looking to adopt these with renewables and assessing, you know, how can we use these systems also used with like wind energy.

Here is a slide that we got from what AEP was doing with peak shaving on the former, let's see, on this substation down here at Charleston Substation. And basically this is some of the data from that where here you are charging during the low demand, using that to discharge during the peak hours for substation bank relief.

And they've also done some studies to look at what monies they could make with arbitrage on that. It's been fairly significant.

This is EPRI's sodium sulfur battery

project that we're doing with NYPA, New York Power Authority. And basically we're documenting this project and looking at it, the lessons learned. It's just about ready to start operation at a customer in a peak-shaving application.

One of the other things that we do is the test and validation of various advanced battery systems. And here are two that we're looking at, this alternano 50 ampere pack. And also we're looking at a case study with a premium power block 150, which is 150 kilowatt hours actually rated at 100 kilowatts.

And we're conducting a case study of an alternano 1 megawatt lithium ion system that's using this alternano 50 ampere pack that has actually been tested with AES. And we're documenting that in a case study.

And we're also conducting a case study test in Knoxville with this premium power zinc bromine system. And one of the things that we've been asked to look at is the performance of these systems with renewables like wind energy. And for frequency regulation.

I'm working on developing a field demonstration initiative with this transportable zinc bromine system that actually is Premium Power who's the vendor. It's a half megawatt, 2 megawatt hour system.

And we've had many of our utility advisors say that this is getting to be about the right size where they'd be interested in putting this at a distribution substation for relief during times where there could be overloads. And getting them through the peak times.

At the same time we want to look at this, it's a candidate technology for wind integration, as well.

Right across the hall we have our electric transportation group that are doing a lot of work with plug-in electric vehicles and electric vehicles and everything. And because of that, lithium ion batteries, this technology is very big in the transportation sector. And we're hoping to take advantages of what they're learning in there that could reduce the cost for lithium ion in stationary energy storage applications.

A little over a year ago we had a summer intern who did a project, and basically what we're looking at, solar photovoltaics and combined with energy storage. And, you know, how could that benefit the infrastructure in California, looking at it from a utility perspective.

And basically the overall load shape curve at that time was about here. And looking at an assumed amount of PV could reduce that peak. But if you could add storage to that, we saw where this overall peak could be greatly reduced.

And so if storage is added the benefits would be enhanced significantly. And especially by the fact that storage is dispatchable. And, you know, unfortunately even though PV, as it has been said before, pretty much matches the peak here in California, still there's some times when it may not exactly do that.

And then in the same study the combination of distributed energy storage was put with solar PV, and two benefits came out of this complementary peak shaving. Solar shaves the first half of the peak and part of the second. And storage could do the rest, whatever it didn't do.

And also another benefit was reduction of installation of balance the system cost, primarily because both could use a combined invertor.

And then there was economic analysis, which I won't get into, using a tool that kind of showed this.

Now, we have a couple of projects that we're doing this year actually, looking at energy storage solutions that will help enable PV and support customer peak load shifting.

We have developed a functional specification. And the idea is that we're testing various energy storage systems that could be used in combination with PV with a smart controller. And this is kind of shown more on the next slide here.

We have this initial specification of a 2 kilowatt, 10 kilowatt hour battery down here, energy storage battery. And basically operating in combination with this PV, 3 kilowatt PV array. The idea of if we had communication to the utility through automated metering infrastructure, a smart meter or other communication systems right here, the idea of this system here would be to keep the residential house energy bill as low as possible, and also be used by the utility to help make sure that if, for some reason, doing this -- well, basically to help shave the system peak.

Now this might occur at the same time as reducing the peak demand at the household. But, basically that the utility could be able to call on this as well as the house owner, so that there would be double benefits for doing this.

And finally the last project that we're doing this year in this year's base program, and Robert had kind of put this up here, as well, K system requirements in cycles to support large wind.

It's a twofold objective. To identify the various K system design, of which there's a lot of different designs, but which design is best in supporting wind resource penetration. And what can it do, basically what are the opportunities that K could be used in supporting wind.

Basically one of the main things is moving offpeak wind energy to onpeak demand time periods. And then also to mitigate wind generator fluctuating power issues. Another could possibly be maybe a regulation of some type.

But those are the two main things. And we think that even though a lot of times folks in the wind energy community don't see -- they think that wind could just be connected to the system.

We think that the utility would like to be able to get it at times when they really need it, during the peaks, and have it stored like during the offpeak so they wouldn't have to worry about turning down their baseload plants and things like that.

So, that's all I have to say for now. If there's any questions, maybe I could field those later.

MR. GRAVELY: Thanks, (inaudible).

MR. BRAUN: Thank you, Bill.

MR. STEELEY: Sure.

MR. BRAUN: Our next few speakers are going to touch on some things that were mentioned earlier. Merwin's presentation mentioned various distributed generation as an additive to some issues on the transmission system.

And in my talk earlier I mentioned that some renewable technologies are already being deployed, and can either scale up or scale down into the mid-size range, the mid-scale range, the community-scale range. Photovoltaics is scaling up into that range, and wind technologies certainly can -- is modular enough to be scaling into the community scale.

So the first speaker I'm pleased to introduce is Joe Henri with SunEdison. And SunEdison is a company that's making its mark in deploying and financing solar electric systems.

MR. HENRI: Thanks very much. Does anyone here in the audience have a solar system on their home, by any chance? I have to confess I don't, either. They're very expensive, which is why I'm particularly excited about the idea of community solar. Because it's a way that more people can get involved in having solar on their homes, or the whole community could install solar.

But there are some challenges, and I'd like to go through real quickly perhaps some of the background on photovoltaics. A lot of folks know quite a bit, I'm sure, about it, but I'd like to review some basics. And also talk a little bit about some of the financing that goes on. And I promise not to take very long doing it.

So, quickly, this is just for credibility, not commercial purposes here. SunEdison is 450 employees in North America. We have offices across the country, also in Canada and Spain.

Our service that we provide is we focus

on the nonresidential market, so we're not doing households or roofs on your house. We do work with large retail customers, government customers and other nonprofits.

A couple of noteworthy things about SunEdison, just in terms of giving you an idea of what scale of things that we've done. We're developing a large solar farm up in Ontario, 9.1 megawatts. We've brought up and are operating a solar plant for Excel Energy in Alamosa, Colorado. It's 8.2 megawatts. And we've just announced a project we're going to be doing for Duke Energy in North Carolina, which is 21.5 megawatts.

So we're on a completely different scale, perhaps, than what we saw a little bit earlier with the concentrating solar. We're not nearly as large yet, but, you know, as we were just saying, Gerry was saying earlier, we're growing. But we're still pretty small.

Well, that being said, photovoltaics has arrived. I mean it is functional, it really works. And as long as the sun is shining, you know, we're making power.

This is a picture of the Alamosa project out in Alamosa, Colorado. And it uses a variety of photovoltaic technologies. You can see some of our trackers there in the upper right-hand part of the screen, as well as the fixed panels.

So, very quickly, just to go through some of the old PV myths. Primarily that PV's too small and it's too expensive. Well, there's a couple of different ways that PV gets deployed. We see it being deployed in distributed generation. We just had a couple of great presentations here about distributed types of technologies.

The California Solar Initiative is arguably the best rebate program in the United States. We've, through the CSI and through other programs that have been administered by the CEC and the CPUC, we've installed well over 300 megawatts of grid-connected PV.

And at 18 months, more than 11,600 applications for photovoltaic systems have been received by the CSI program administrators. By number of applications, primarily residential. But by number of megawatts we're talking mostly commercial applications.

So, just to be clear, on DG we're talking about systems that are installed on the customer's side of the meter where they reduce the customer's load.

We are also seeing a larger deployment now of what we call utility-scale PV. So these are the vast fields, like Alamosa, for instance. But we're not the only ones doing that. So Excel Energy in Colorado, 8.2 megawatts; Nevada Power, of course in Nevada, is 14 megawatts at Nellis Air Force Base, that was a SunPower project.

And then we've seen announcements for Southern California Edison in their RPS. There's a first solar project, a 21 megawatts. Again, our Duke Energy project, North Carolina, 22. And then Florida Power and Light, 35 megawatts of total projects.

So we're beginning to see some very large scale stuff happening in photovoltaics. It's not too small, it's actually getting bigger, and we're actually having some scale where the economies of scale can really make a difference for us.

So, costs. Now I stole this chart from a presentation that was done by the National Renewable Energy Laboratory. So hopefully that gives it a little bit more credibility. It's not just wishful thinking on the part of the photovoltaics industry.

But if you take a look at the bottom part here, we see this blue line is the cost -- this is the typical average cost across he United States for wholesale generation prices for utilities. And then this bar here, the yellow bar, is the residential and commercial rates. The descending sloping area here is he cost of photovoltaic systems.

So, what we're seeing is that manufacturing technologies improved. More and more sources of silica are arriving on the market. We're seeing more and more competition and more and more players. System prices are declining rapidly.

And you can, according to this chart, depending on where you are, what state you're in, we're looking at grid parity at somewhere around 2012. Deutchebank also came out recently with a similar assessment. They basically came out with something very similar in terms of when they expect to see grid parity.

All right. So, prices are coming down. We're seeing a lot of different types of deployment. Why aren't we seeing more happen at the community scale? Let's talk about that a little bit.

Oh, I'm sorry, before we go on, an important new financing tool, too. So this is also helping to deploy a lot of solar. The power purchase agreement. So, how many folks have ever leased a car? Anyone? At least one, two, three. Okay, good.

So, this will be easy for you. With the power purchase agreement the difference between this and a conventional solar sale is that the customer doesn't buy the system. They just buy the power. So that the facility, the solar system, is owned by, you know, SunEdison in our case, or by the other PPA provider. And only the electrical output of that system is sold to the customer.

This has some advantages, of course. From the customer's perspective they don't have to operate or maintain the system. And they only pay for what they actually get. From the perspective of the PPA provider you can do larger scale projects, you can attract financing from Wall Street basically to invest in your funds, to own these systems.

And the cost of doing this, if you're focused on the larger scale systems, can be driven down quite dramatically. That's the whole premise of the SunEdison business model. And you're seeing a lot of other companies to it, as well.

So, just to go over this again, real quickly. Basically the -- here's your handy-dandy SunEdison solar system up on the roof of a large commercial project. Kilowatt hours are sold to the host customer. Host customer pays only for what they get out of that system.

But it's also important to note that the customer isn't going to get all of their power needs met by the solar system. Probably 40, 45 percent max is what we typically see. So their remaining energy needs are still going to be provided by their trusty utility company over here.

There are different PPA arrangements, of course; different companies have different focuses and have tried different things. But almost all PPAs have the same basic provisions, payments based on actual system production. They're usually about 20 years long and there are early termination provisions.

You have to deal with what happens to the system at the end of the contract; what are you going to do with the renewable energy credits. Will there be green claims; are the credits retained by the host customer or retained by the PPA provider.

And then in the event that the PPA provider goes bankrupt or something like that, what happens to the system. You know, who owns it afterwards and what's the disposition. All those things have to be covered in the PPA arrangement.

So, community solar. Here's an idea that we've been talking about at SunEdison and trying to figure out how to deploy. But we've been unsuccessful and I'll talk about that in just a minute.

But the idea is pretty simple. Basically you have a system, a centralized system, somewhere. You can put this on waste land like a landfill, or on a military base or something like that. But the system provides energy and green attributes to your local electric distribution company. Who then sells that power to individual customers who have signed up for getting solar power.

So, SMUD, for instance, Sacramento Municipal Utility District here has what they call their solar shares program. And it's not exactly like this, perhaps, but it's the same concept. If you subscribe you can basically own a portion of a larger system. It's not on your house, it's somewhere else, but you're going to have that piece.

So, that's the idea of community solar, at least in our minds, is that you've got centralized, you know, perhaps these are distributed across rooftops on city properties, or large commercial properties throughout the city, but individual ratepayers over here can own a portion or subscribe to a portion of that.

A model that might be kind of similar here, server farms, for instance, if you're familiar with how that market works.

So, the folks over here are getting solar energy. There's an opportunity for training and community development. So if these are low-income folks, for instance, and you're putting your centralized solar system on an area close to a low-income community, this might actually provide jobs and training.

And then California's renewable energy goals are also being met because this is clean, nonemitting generation.

So, just to go over it real quick. The, what we call solar parks, could be developed almost anywhere within a city limits. Utilities would purchase the power directly from the solar park at fixed rates with special purpose tariffs or through bilateral arrangements. And then utilities pass that through to participating customers. And there's different ways that could show up on a customer's bill. It can either be dead metered, which we do today. Or you could do it with sort of a fixed billing credit instead.

So, that's a concept. That's a way you could get solar into a community. It doesn't require that anyone put the money upfront to actually put solar on their own rooftop. They could apply to residential customers, it could apply to commercial customers.

So, why aren't we doing it? It seems so simple. The technology is certainly there. Maybe the best way to describe it is it's a software problem.

So, we've had something called community choice aggregation, which was legislation that was approved here in Sacramento. It's been under various, it's been implemented, you know, for a number of years now. It's going through an implementation process, perhaps is the best way to put it, a the Public Utilities Commission.

And that has basically taken the wind out of any other opportunities. CCA, unfortunately, is still not a successful program. And the idea here was that a community could decide to become its own -- have its own generation portfolio that would then be delivered through their utility grid. Well, it's a great idea, it just hasn't happened.

Another barrier that's in the way, electric sales to retail customers is called direct access if you're not a utility. And in California ever since the energy crisis, direct access has been suspended. So that's not an option anymore.

Fifteen -- ten years ago, you could have gone to Greenmountain Energy or someone like that and done this, but you can't do that today in California.

And then finally, even if you weren't going to pursue those other options, what if the utility was just going to do this, utilities generally call this retail wheeling. And it's not really a popular option simply because it's complex in terms of the billing. You have to have new tariffs and you have to spend a lot of time and effort to figure out exactly how to make this work. But as I said before, it's not a hardware issue, it's a software issue.

All right, so what else can communities do if they're really interested in installing solar. So, it's really important to remember that your local government can have a huge impact on the cost of solar. Not just on the panels and the racking and the invertors and those types of things, but on the other costs that go into installing solar. Because every solar installation has to be permitted and it's always local.

So, streamlining permitting processes, making sure that your local utility allows interconnection to the grid. And, of course, with the investor-owned utilities in California, that's not a problem at all.

And then there are some other things, as well. I won't read that whole list there. But there -- basically the community can also ask itself, what are we doing to encourage solar.

And because we paid good money for these pictures I wanted to put one more picture of Alamosa in there just to remind folks that people are doing this. It's not just here in California, but there are plenty of installations going on in other states across the country. This is real and it's really happening.

And that's the end. Thank you very much.

Any questions? I'd be happy to answer questions while I'm up here. Okay, no questions, thanks.

MR. BRAUN: You answered all the questions.

Our next speaker is Case Van Dam, who is the Executive Director of the California Wind Energy Collaborative. I mentioned the Collaboratives earlier. And Case is going to give us a view of wind at the community scale, and some experience from where that's happening.

MR. VAN DAM: Thank you, Gerry, for the

introduction. So, yeah, wind community in building industrial scale, we've gotten involved in that over the last year. More and more because of increased interest in solar as indicated by the previous speaker at the residential and community-scale level. And also very much interest in wind at those scales.

So, like to also acknowledge the two co-authors, Henry Shiu and Scott Johnson, two engineers working with me.

I'll go through this fairly quickly actually; it's getting a little bit late in the afternoon, and you have all the material. So I'll step through this fairly quickly, but I think it gives a good overview of what's here, what the possibilities are.

So, look a little bit at the industry status, system configuration and costs, economic considerations. And then a particular case study, an agricultural case study. And I think that is growing more and more interest, I think, from people. And also some future opportunities and some hurdles that we still face.

So why wind energy? We've heard quite a bit about that. It's clean, it's renewable. The installation, it can be rapidly deployed once the permitting process is dealt with.

Noncentralized installation and operation provides security of electric energy. And it is economic, cost effective energy. And it provides some significant local economic benefits.

So wind, big and small, a lot has been said about utility-scale wind energy, and there you see the typical sizes in terms of rated power capacity, 1 to 3 megawatts; rotor diameters up to and out 300 feet height. That sometimes exceed 500 feet. And it is, of course, very much focused on the utility-scale.

Power generations supplying power directly to the grids. And the small distributed, much smaller, of course. There we're talking typically small distributed wind, less than 100 kilowatt.

Rotor diameters about 60 feet height, less than 150 feet. And I have to get some water somewhere.

And so here we are much more interested in the powering nearby -- thank you -- providing power for nearby applications.

To put it all in kind of -- make it all

visual, on the right-hand side you see a blade for a very popular Southwest Skystream, 1.9 kilowatt machine. And on the left-hand side you see the blade for Vestas, I think it's V80, maybe actually be even a V90, which is a 3 megawatt machine. So, very different.

And here then you see the typical applications of residential and also community-based wind. These are fairly small wind turbines in this case, 200 kilowatt or less. Stand-alone hybrids, on-grid and off-grid.

So, let's look at this industry in a little bit more detail. What is actually not well recognized, the U.S. dominates this market. This is one area we still, we dominate the small wind market.

If you look at here the outside the United States 2006 sales, 19.5 megawatts, $61 million, 97 percent manufactured in the U.S. And what industry do we hear nowadays 97 percent manufactured in the United States. In the U.S. 2006 U.S. sales, 98 percent manufactured in the U.S.

But, again, we're facing more and more competition. There's a lot of companies popping up in Europe and Asia. And I think this story is going to change in the coming years. U.S. market growth estimates at 14 to 25 percent annual.

But notice that the total numbers are fairly modest compared to, you know, here you look at the 17.5 megawatts and 19.5 megawatts. So, about 38 megawatts or something like that. That's less than SMUD's installed over the recent year in Solano, using a few V90s.

Offgrid, where this here is ongrid typical configurations with a battery backup or just the basic system just behind the meter. No storage at all. We still see a lot of offgrid, of course, applications here. You see here with just wind alone with the battery storage. And then, of course, you can also hybridize the system with PV, optional, you know, the diesel generator for instance, and then your battery bank.

So let's look at the cost then. What are we looking at. And the photo shows a 10 kW Bergey, Bergey Excel, as one of the more popular systems. This installation is not too far from here. You can see it from I-80, it's near Dixon.

This is a 10 kW system. $41,000 not including permits. And that is also -- so no rebates involved. So it is very competitive at $4 per watts.

Let's look at a little bit newer system here that's drawing a lot of attention. I pointed out before, the Southwest Windpower Skystream. This is a 1.8 to 2 kilowatt system depending how you configure it. And this is, of course, on a little bit different, a monopole, a little more expensive as a result. $12,500 not including permits, and of course, also not accounting for any rebates. So, again, a very -- still a very competitive price.

So then, zeroing a little more into the economics, the economics of utility-scale wind, small wind, they are very different. System costs have been fairly steady at $5 per watt. About 15- to 18-cents per kilowatt hour. Again, these figures do not include incentives. Compare that to utility-scale wind, right now we're talking about $1.80 or so per watt for installed, looking at 4 to 7 cents per kilowatt hour. So very very different numbers there.

But still I think because of the different application now we competing or we're looking at things behind the meter. So, net metering and incentives substantially change the economics of these systems.

Because now you're looking at these kind of rates, of course, 11 to 36 cents per kilowatt hour; average 16 cents per kilowatt hour when you look at the residential single rate. And then it's up from there in California, depending on your energy usage. And you'll see that also in the example I have a little later on for an agricultural application.

The incentive programs are very important, and California definitely is the leader when it comes to its emerging renewables program. You see here some of the numbers from zero to 7.5 kilowatts, $2.50 per watt, and what is interesting to me, there's still a lot of people -- getting a lot of calls about what the federal government can do for you in terms of providing rebates or tax cuts for systems. And when you point out to them that California has one of the best rebate programs in the country, maybe even in the world, a lot of people are quite surprised about that.

Because this is, if you look at that, this is about 50 percent of the total cost of a system in terms of what you get back in terms of the rebate.

We also have the STIP program. And then as you go to agricultural application, USDA has also a very nice program providing grants and loans.

A lot, on a regular basis nowadays we get calls about new small windpower systems. And you see some pictures there of some of the systems that have entered the market or are trying to enter the market, as we speak.

Wind turbine designs, however, have evolved into the current configurations, -- it's a little bit different from these, for sound engineering and economic reasons. You have to be a little bit careful here, but many of these manufacturers are going through some very detailed testing programs to develop their products.

So when you talk to potential customers you always point out the eligibility for the California ERP rebates is one indication that a turbine is reliable.

There are some requirements in order to get onto this list. And I think it's important to only look at the equipment on this list.

What is actually even more encouraging,

the small wind industry is working on a turbine certification program. And that should hopefully fall in place next year. And I think that will very much help potential customers to kind of give them a better feel if the turbine that they are interested in buying, if it has been vetted.

Because right now the proof is still in the pudding. You know, the best indication of a good turbine is a history of successful operation. And that makes it sometimes difficult for these newer systems, because there is really, quite often there's no or very little operational data.

Here is actually the current CEC ERP small turbine list. You see the Bergeys there; you see the Southwest Wind Power; you see some newer players, too. It's kind of interesting, I check this list once a month or something of that. And on a regular basis you see new products popping up on this list indicating the interest in distributed wind. New companies like PacWind here. We see here also on the bottom here, looks like -- I'm not quite familiar with this product, but a Chinese product popping up, and others.

The largest you see here is Northern Power Systems, 100 kW. And then we see also one or two 50 kW systems on there. But most of them are in the 10 kilowatts or smaller.

So, how do you go about, you know, picking the system first. Is wind right for a particular application, distributed application. And then the first one we always point people to the ordinances and permitting requirements.

And I think talking about one of the biggest hurdles which we still face in California is the ordinances and permits depending on the locale. And then you do your -- perform the energy production and economic analysis.

The ordinances and permitting, pretty well known. Here, for instance, we have an example from Monterey County. This is for small wind, a minimum of two times the total height from property line. Minimum of at least five times the height from any public road or highway. Minimum of at least 1.25 times the height from any habitable structure. That's the setbacks and then the heights. Maximum total height may be limited to 100 feet.

And then the issue for permitting fees. Again, very variable in the state. Some counties just charge only a few hundred dollars; others are much more expensive. Monterey County is probably the most expensive county in the state, I think. For a small wind system right now when you like to permit that in Monterey County, the starting price is $3500. So that is doubling the price of the system pretty much, if you look at a 1 kW system, for instance.

So, let's look at a case study, irrigation in Salinas Valley. Two wells; each well right now they're operating two 50 kW pumps. Here you see the two wells, and they are two different rate structures, AG-1B and AG-5B.

Here you see the total energy usage, and it is almost -- it is quite significant. The total cost for a 450-acre ranch, they spent in 2007 $42,000, more than $42,000 in electric costs to operate the pumps.

So we looked at could you do something in that area with wind. And this is the wind resource nearby. It was -- you see here the hour of the day. So midnight, midday, late afternoon. And then this is time of the year, January through December.

The bright colors indicate the higher wind speed. So definitely, if you look at the temporal signal, things look good. Good winds during the summer in the late afternoon.

In an absolute sense the winds were not all that great. They were fairly modest, actually. So even with, as you see in a moment, even for the smallest wind site, the payoffs were pretty good.

So we picked this the wind turbine. Again, I have mentioned a few wind turbines here. We just picked them as industry examples. We are not getting anything from these manufacturers in terms of mention of products. We are not working on any of these turbines.

So this is Entegrity EW 15. We picked this one because it is a little larger, 50 kW. Put it on a 100-foot pole. And then also important from the agriculture application, we looked at the footprints, how much land you need for this turbine to be installed, including guy-wired and any foundation.

So here's the economic analysis. And to give you an example what can be done with these kind of systems. Here for well AG-1B, we had actually there the one 50 kW machine, which provided about 70 percent of its energy on an annual basis. Energy cost savings about $10,000. And then after the rebates turbine cost is -- here we're talking about a much larger system, $215,000. SGIP, USDA final cost $86,000. Simple payback period 8.2 years.

For well two, because of the different rate schedule, it was not as attractive. Here the savings was about $6700 on an annual basis, and a simple payback period give you about 13 years.

So, ways to do things better. If you can do any peak demand shaving; this is especially true for well two. The rate schedule, and that, of course, with energy storage option, batteries, maybe water towers, the economics may look a little bit better.

So, with that I'd like to jump to my last slide. We believe that wind energy deployment at community and distribution levels in California would yield benefits for everyone. I think reduce the electricity needs. I mean the electricity needs from the grid and the cost for the operators. Definitely significantly reduced emissions.

California is well situated to maximize the benefits of wind energy at community and building/industrial scale. We have a fairly decent wind resource. It is not great, not as great as in the midwest. But there are some areas of excellent wind resource in the state.

We have a terrific net metering program. We have a terrific rebate program. So those are all on the plus side.

And then here we come, here are the negatives. We have a kind of a very scattered permitting requirement. It's not very uniform. It's not very transparent.

And it is do-able if you permit, maybe, a utility-scale wind plant. If you're installing 150 megawatts of wind energy you can afford a few layers to deal with these issues. If you install your own little wind turbine, you have much less time to deal with these requirements.

The fee structures are also kind of varied quite a bit across the state.

And last, but not least, there is this issue of equipment verification. And the good news is that is coming. I think in the coming year we will have a certification program in place for small wind. And I think that will definitely make it much easier for the consumers to pick equipment that is right for their application.

And that ends my talk, thank you.

MR. BRAUN: Any questions? Yes.

MR. KULKARNI: I was wondering, does your payback figure take into consideration the investment tax credits -- or are they just plain savings?

MR. VAN DAM: It's a very simple payback, yeah. This is the final -- is the cost after. It doesn't even take into account any federal tax, depreciation or anything else, no. It's just looking at the cost of the system divided by the savings. And that comes up -- that leads to the simple payback.

MR. KULKARNI: So it might look much better in -- and that's with the real money in your pocket?

MR. VAN DAM: Yeah.

MR. KULKARNI: Okay.

MR. VAN DAM: Yeah, I think if you start to take in some of the tax benefits and et cetera, it would even be shorter, yeah. Thank you.

MR. BRAUN: Okay. I just want to mention that for those of you who picked up the handouts early in the day there are a couple more that are out there. So, as you leave, don't forget to pick up the ones you didn't get.

MR. GRAVELY: So, we have most of our speakers still around. And I'd pose it here, if you have a chance, take a chair, if you would. Go ahead and -- take your questions.

And I'd like to remind everyone that we do have -- one of the handouts here is a series of questions. And feel free to augment these comments with comments of your own. But there are some specific statements and comments. We're interested in your assessment of the validity of the emerging technology information, and also your comments on some of those things.

So, I think what we're going to do is -- comment session, we have one, just one, right, presenter?

MR. SPEAKER: We have two.

MR. GRAVELY: Two presenters that are going to present briefly for us some technologies that are specifically oriented towards increasing renewable power -- in California from different ways.

And I think our first speaker is here today from 3M.

MS. JAMES-KING: Good afternoon. I'm Suzanne James-King from 3M's ACCR, aluminum conductor composite reinforced, as an innovative, high-temp, low-sag conductor that is a way of helping to provide renewable energy to attach it to the grid. And also to get more power on the grid for you.

Basically this is a product of 3M's diversified technology. 3M, most of you know, to introduce, in 2007 did a little over $24 billion in worldwide sales. We sell products in nearly 200 countries. We have 76,000 employees with 34,000 in the U.S.

And what we strive to do is provide practical ingenious solutions to help our customers succeed.

In California alone, 10 percent of our U.S. employees reside here, a little more, 3511 employees and retirees are in the State of California. With a total payroll of over $139 million.

So what is 3M's aluminum conductor composite reinforced? Basically it's a high-voltage, overhead transmission conductor that was designed as a drop-in replacement for traditional steel core conductors. To be used on existing thermally limited lines, to allow utilities to use their existing structures and assets, and yet carry two to three times the current.

So, if a utility's upgrade, they're looking at a large capacity increase, as I mentioned, two to three times their existing line. They're looking at a costly or risky construction process. They're looking at modifying or replacing structures.

They could be looking at challenging installations such as waterways or highway crossings or canyons through forests. Everyone needs lower cost and quick back-to-service. They want a highly reliable proven solution. We all want that. Then that's when they should be looking at 3M's ACCR.

How we do this is simply, as I mentioned, it's a high-temp, low-sag conductor. In this example we're looking at a traditional steel core conductor, ACSS, compared to 3M's ACCR. As a function of weight, if all your design and weather conditions are the same, a steel core conductor will hang lower at ambient temperature, as a function of weight. The steel core weighs about twice as much as 3M's composite core.

Now, as you put current through it, though, the aluminum matrix and the 3M core does not expand as much as the steel core does as power goes through it and heat increases.

Therefore, in this example at 75 Celsius and a little over 800 amps, as steel core conductor would hit the sag clearance, and at that point the power transfer is limited because of sag clearance.

However, with 3M's innovative conductor you can keep putting the power through it up to 240 Celsius, which is the emergency-rated temperature of the conductor, and almost 1800 amps before that sag clearance would be met.

That's how you are able to put more power through the conductor on existing structures under existing design conditions.

This is a breakthrough in material science by 3M scientists. They were really looking for a new metal to use in jet aircraft engines for the Department of Defense. And what they came up with was an aluminum oxide fiber known as 3M Nextel Fiber that they then embedded with pure aluminum to make a core that's all aluminum based, combined with aluminum zirconium on the outside. It gives you a strong, lightweight conductor. Think of this as the strength of a steel core conductor with the weight of an all-aluminum conductor. Low thermal expansion and a high modulus.

High modulus, it doesn't stretch very easily, so it's ideal for ice loading, wind loading conditions, et cetera.

So what do you get? You get consistent performance at high temperatures, less sag, as we've talked about when you're putting high energy loads through the conductor.

A transmission operator is able to match their existing load, tension and clearance requirements on their assets.

At the same time they get less stretching. They have corrosion resistance without barriers between the core and the outer wires. Also, because it's aluminum and aluminum behaves like an all-aluminum conductor in regards to corrosion resistance.

Durability. We all want things that last a long time. Conductor and accessories are rated to last 40-plus years, even at high temperature. 210 Celsius is what this conductor is rated at to run continuously for 40-plus years.

Again, as I mentioned, a capacity increase of two to three times the traditional conductor. And it's a proven, reliable solution that's been installed and in the field with no failures. We're very proud of that track record.

It's also very easy to use. It was designed as a replacement for steel core conductors. And the accessories and equipment are designed to be installed and utilized very similar to a steel core conductor, a traditional conductor. It's easy for contractors and utilities to adapt.

So, when should an outfit look at reconductoring, rather rebuilding. Initially when more power is needed down the line there are some low-cost things that can be done to gain capacity, low capacity, but low cost.

But eventually when you start looking at 25 percent or more new towers, or you're looking at some permitting restrictions, et cetera, then 3M offers an alternative.

So what we go after and what we're usually used for are the most challenging applications. Things like long-span crossings and special siting situations where you don't want to put towers in waterways, for instance. Or you want to lessen the environmental impact.

Corrosive environments. As I mentioned, corrosion resistance is very similar to an all aluminum conductor. So, without protective coatings being required, even in coastal and high pollution areas, this conductor performs.

Changing clearance requirements. Whether it's a railway, a highway, a roadway, waterway, et cetera, less costly and faster. Densely populated or under-built areas. No one wants a tower in their backyard. And they particularly don't want an additional tower or a taller tower. Therefore, we can help out in those areas.

Additionally environmentally sensitive areas where you don't want to change the footprint of the towers that are there; or you're looking at ridgelines, et cetera.

Heavy ice regions. I mentioned with a high strength-to-weight ratio, high wind loadings, high mechanical loads, this conductor performs.

Aging structures, a lighter conductor

can help make existing assets last longer. And last, but not least, when you're connecting new generation or renewable generation to the grid, often the lines down below become overloaded. You can upgrade those lines, increase the pathway on the existing assets.

So, by maximizing the upgrade value you can maximize the amps by doing things by increasing your unit cells on existing assets. That benefits your ratepayers by spreading fixed costs over more kilowatt-per-hour sales.

Greater reliability and usable capacity. N-minus-1. If one line goes out and power needs to come down another line, by having excess capacity on that line you can keep the power flowing even in times of a line outage or a generation outage.

Flexibility and responsiveness. Growth can be variable, we all know. Areas grow very quickly, they grow slowly. It's hard for planners in looking at 20-year plans to really know what's out there. Extra capacity on a line provides for that.

You can delay the next upgrade. What's the point of upgrading now when you know in three to five years you may need to upgrade again. Spending the money now often additional capacity continues to serve load growth longer.

And there's a certainty of project costs and timing. It's well documented in the literature how construction costs, material costs, et cetera, can highly exacerbate and end up totally blowing out what was originally a very well thought out budget. When you've got more certainty of project costs and timing, reconductoring can help you do that, and help utilities and other transmission owners stick to their budgets.

And last, but not least, 3M's been in business now for 106 years. We're here with the State of California, and also with the utilities, transmission owners and generators to be here all the way, from design concept all the way through to energization.

Thank you. Any questions?

MR. GRAVELY: Thank you. I would like to mention that for those who are interested, Jamie could help us here, but there was PIER research done on this technology and some field testing done through a research program. It's also available if anybody's interested in that area. So this is a technology that has evolved from PIER.

And we have one more speaker?

MR. BRAUN: We have one more.

MR. GRAVELY: Okay.

(Pause.)

MR. HEINRICH: I'll just make a couple points. My name's Mike Heinrich from EPRI, and I'm sure you're happy to hear another EPRI discussion.

But I want to make just a couple points about the need for grid planning and grid operations. Merwin and Dariush both referred to the need earlier in the day for different ways of operating the grid, and different ways of planning.

EPRI has, this year in the 2009 portfolio, which we roll out -- we're discussing now -- a new program that's called program 173. It is for basically the renewable integration. So it's right on the topic of today's discussion. So I just want people to be aware of it.

I won't go into a lot of detail. The slides that I'll make sure that we do get them, and they'll be available on the web.

I want to point out two other areas in the area that we talked about earlier. Also the need for decision tools and forecasting tools, not for forecasting the wind, but forecasting areas where we've already done some work together with the PIER group.

One for critical operating constraint forecasting; done the first phase of that project. And we're looking, in discussions with the CEC, to do a follow-on phase for that.

And the other one for congestion forecasting. And this is particularly associated with the congestion that may be seen with the additional new resources that we have for both wind and solar and other types of renewables.

So, again, my comments are brief. If there's any questions on these, please get ahold of me or get ahold of Mike or Jamie, and they can get ahold of us.

So, thank you for your time. And I know we're pushing towards the end of the day, so, thanks, again.

MR. GRAVELY: Thank you. I'd like to open up the floor here for -- actually, maybe we'll talk with the WebEx group. Is there anybody, you guys haven't had a chance to ask any questions, I haven't heard any from the WebEx crowd. This is unusual for an all-day event not to hear anybody.

So, are there any questions online for any of the speakers that we have here today?

I guess not.

Are there any questions in the audience for any of the speakers we have today?

Go ahead.

DR. ZACK: I noticed that there were a number of different possible solutions to allow higher level penetration of wind and solar, such as storage and forecasting, of course.

I didn't hear a lot about the interaction of all those solutions to optimally manage the grid. So where do we stand on the idea of, for example, if you have storage on the system you might use wind and solar forecasting differently than -- and if you have forecasting, maybe you deploy storage in a different way than if you don't have accurate forecasting, or you have accurate forecasting over certain timeframes. That may change how you deploy storage.

So, does anybody have any information about how that type of investigation is proceeding?

MR. GRAVELY: Robert?

DR. SCHAINKER: Yeah, maybe. I'm sorry, I was working on something else when you started your questions. I missed the beginning of it.

But, explain your question again.

DR. ZACK: Well, how do you use all the different resources we've heard about today as a combination to optimize the management of the grid and allow higher penetration?

So, rather than say storage is the answer, or forecasting is the answer, how do we put them all together optimally?

DR. SCHAINKER: Nobody's done that. But there is some infrastructure issues here. Right now, the way the ISO operates here in California is that each plant sends a bid in for the next day for so many hours and so many megawatts.

So, the -- and a good operator is not authorized, or his job is not to optimize the integration of all these things. He's just got to make sure the grid is reliable.

So, there is no mechanism, even in the

State of California, would do as you suggest, which, in fact, would probably save money for the customers and be better reliable, et cetera, et cetera.

That's not the way the system works right now. In the old days when we had an integrated vertical utility system we could do that. But that's not even in the cards right now.

So I don't know if we want to go off on that topic --

MR. BROWN: Okay. Can I add something to that?

DR. SCHAINKER: Yeah, sure.

MR. BROWN: If I may. And I'm not countering what you say. I'm adding onto it --

DR. SCHAINKER: Sure, sure, sure.

MR. BROWN: -- by looking further into the future. Dariush, for example, mentioned the use of probablistic kinds of planning and forecasting.

To me the way I look at that is that, as Robert said, 20 years ago the grid was operated under plans essentially, deterministic plans. And they were in control almost of everything except for mother nature.

And we've gotten to the point where those plans have largely disappeared. They aren't there anymore. And so everyone's operating, so to speak, in real time.

What I think some of the research that's going on is doing is sort of returning a form of planning to that operator in the terms of being able to do probablistic forecasting. And then you add to it a considerable better knowledge about the grid through such things as these real-time monitoring systems and faster kinds of algorithm and computerization to allow analysis to be done and decision support to be done. And then more automation.

All of that, I think, is maybe bringing this back again to what you're talking about, to begin to talk in terms of a form of optimization. Will it be perfect? Probably not. Never is. And will it take time? Yeah, it will probably take a long time.

But I think that's the first thing where we're heading with the technology capabilities.

DR. SCHAINKER: Yeah, on the other side of the coin a developer of wind, let's say, or solar, whatever, if he or she wishes could put a package together of a wind system with storage, with forecasting like your technologies have, which is fantastic. And I don't think they'd add to it transmission, I don't know.

You could try to put a generation package together that in the dotted box around it is dispatchable renewable. Dispatchable wind, dispatchable -- that could be done.

But in terms of the ISO using your tools for wind forecasting to alter their next day's allocation of resources, that's yet to be done. There's not a mechanism to do that.

DR. ZACK: But are we doing the research to support that type of application? Do we understand how we use forecasting and storage optimally --

DR. SCHAINKER: A little bit. Not too much. In my opinion, just a tip-of-the-iceberg kind of stuff. Maybe 10 percent.

MR. GRAVELY: Let me add a couple things here really quick. There is a working group, and it doesn't specifically address renewables, but most of you area aware that the ISO is upgrading their system under the market technology, I mean MRT working redesign technology upgrade.

We have an infrastructure working group and a products working group that's part of that. I happen to chair the infrastructure working group.

And in that area we are looking at things like that, because we go forward with infrastructure; it's initially focused on demand response, but it's expected to expand to other areas.

How these, for example in wind forecasting model, a question could be how could this model be integrated into the future versions of software that they use for their day-ahead forecast and their hour-ahead, and 15-minute-ahead forecast.

So there is a structural place. And we do advertise those meetings; they're published on the ISO website. And so I would encourage you to talk to the infrastructure working group. These are the things that we are talking about. I mean there is nobody doing all of it.

The other thing that we've learned from our smart grid work from ourselves, is that smart grid, for example, addresses so many areas there's nobody who works them all except maybe the government.

So this is a case where they've said, and this is why we're doing this smart -- we're doing everything else, that this is a case for bringing everybody together and communicating is something that they need somebody to do.

So we're trying to serve the role of bringing together all these different players and seeing how these things fit.

So I would encourage you to look at those two options. Particularly the infrastructure group, because if you're interested in the ISO 24-hour-ahead and day-ahead and day-of forecasting, that's exactly what we are working the infrastructure for. We're working a modification to the software to accept new technologies.

We already have version 1 and version 2 closed out. But the point is these are types of questions that we're asking in that working group, is what's coming down the pike that the ISO forecasting tools need to have in the markets they do address.

So that's an area that I would encourage you to participate if you're interested. And it's an open working group, it's not -- open to anybody who wants to participate.

DR. ZACK: Thank you.

MR. GRAVELY: Any other questions? I guess it is getting very late. I want to thank everybody for participating, and I thank everybody online that's participating. If you haven't had a chance you should be able, certainly by tomorrow, to download all the presentations.

The transcript of this will be posted. And also there is a recording of this that will be posted in the future, also, for those that are interested, for the session today.

Any your comments we have. I also will be working the 2009 IEPR and the emerging technologies for all areas. And I would encourage you to think about how we can most effectively do that.

This one here, I wish we had a little more interchange. And we may plan it a little different next time than we did today. There is a lot of technologies to cover.

We are working to take what we've learned today and integrate that into recommendations for the 2008 IEPR. I would encourage all of you to provide comments as to where you think the priorities should be. And where you think the technologies that are on the verge of being supported and technologies that maybe need to have a more proof of the pudding before we consider them.

That's part of the reason today, and these discussions, is to share with you where we think the technologies are, and hear from a broader audience, if we are in line with what you're thinking or if we're out of line with what you're thinking.

Since there are no further questions, thank you very much for coming, and we appreciate your time.

(Whereupon, at 4:18 p.m., the workshop was adjourned.)

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CERTIFICATE OF REPORTER

I, PETER PETTY, an Electronic Reporter, do hereby certify that I am a disinterested person herein; that I recorded the foregoing California Energy Commission Staff Workshop; that it was thereafter transcribed into typewriting.

I further certify that I am not of counsel or attorney for any of the parties to said workshop, nor in any way interested in outcome of said workshop.

IN WITNESS WHEREOF, I have hereunto set my hand this 25th day of August, 2008.